Utah Science

Volume 41 | Number 1 Article 1

3-1980

Utah Science Vol. 41 No. 1, Spring 1980

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Recommended Citation

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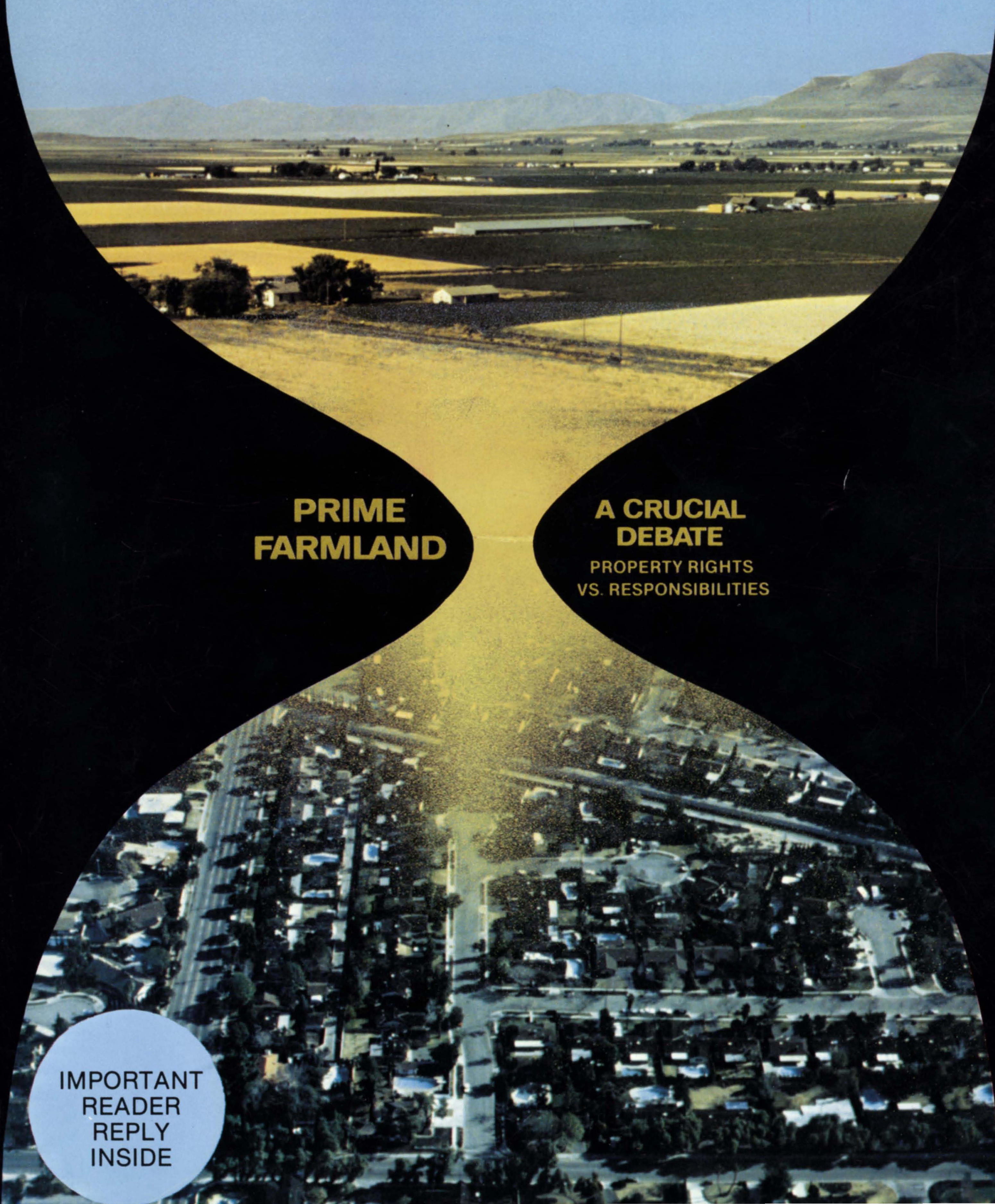
UTAH AGRICULTURAL EXPERIMENT STATION SPRING 1980 VOLUME 41 NUMBER 1

UTAH SCIENCE



PRIME FARMLAND

A CRUCIAL DEBATE

PROPERTY RIGHTS VS. RESPONSIBILITIES

IMPORTANT READER REPLY INSIDE

SPRING 1980 VOLUME 41 NUMBER 1

UTAH SCIENCE

UTAH AGRICULTURAL EXPERIMENT STATION

ABOUT THE COVER

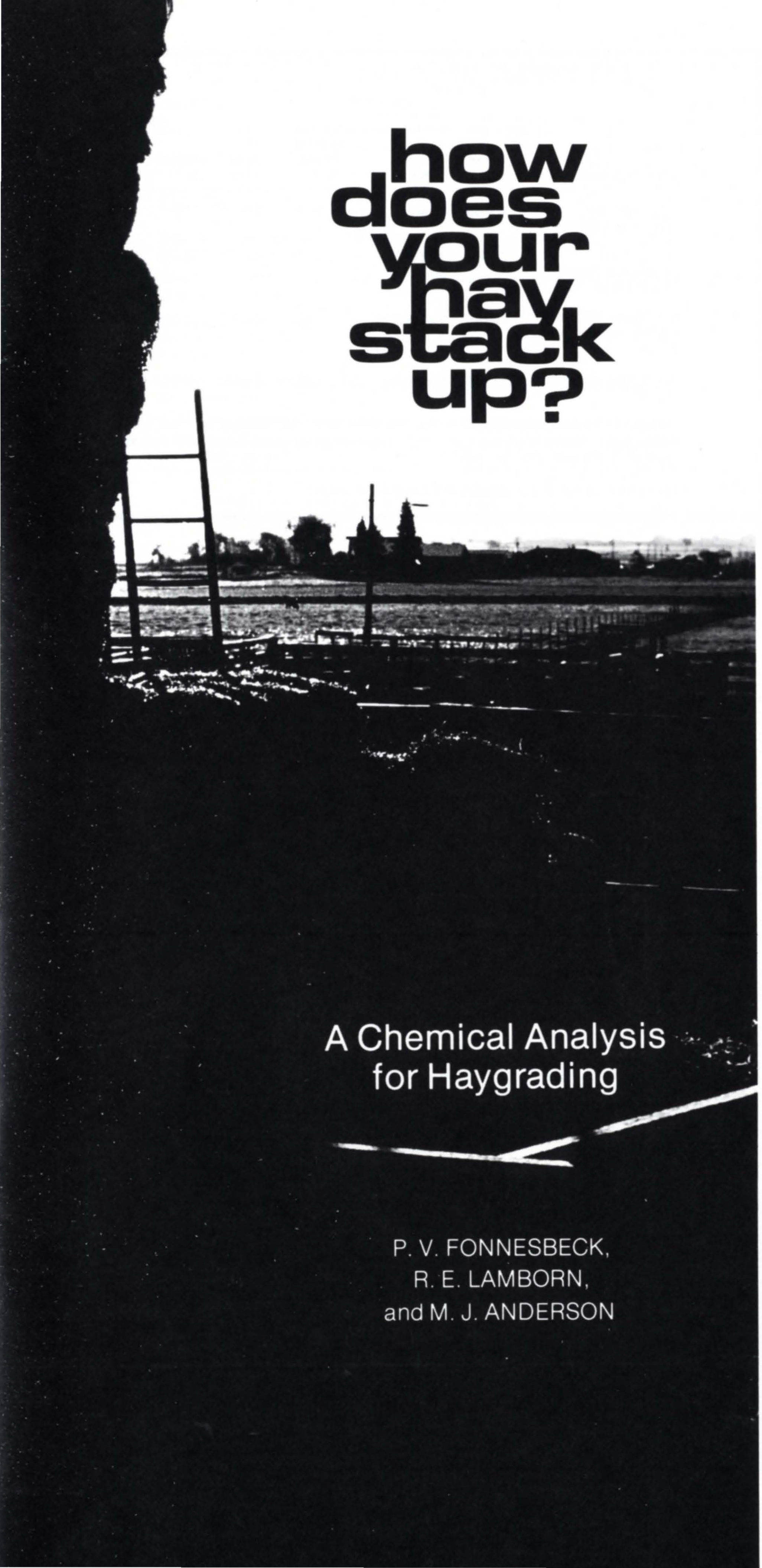
Prime farmlands are being gradually shifted to urban uses—housing, businesses, roads—by economic forces, both personal and communal. No regard is given as to whether we may need these lands again to produce food.

Does it matter?

And if we would need that land again, what price reversal?

The blue center section of this issue has two viewpoints offered for your consideration.

how does your hay stack up?



Carol Grundmann

A Chemical Analysis for Haygrading

P. V. FONNESBECK,
R. E. LAMBORN,
and M. J. ANDERSON

ALFALFA OCCUPIES A MAJOR PART of Utah's agricultural land and is a crucial factor in the state's dairy industry. When some of Utah's dairy farmers asked for help in finding reliable methods for determining the quality of alfalfa hay, a committee was established that included farmers, extension specialists, laboratory managers, and animal nutritionists. The result, in 1978, was the organization of the USU feed analysis service. That service was created to help feeders, buyers, and sellers of alfalfa hay cope with their problems.

Hay is either fed on the farm or sold directly to a dealer or another farmer. The buyers and sellers seldom have access to recent hay marketing information, which makes it difficult to set a fair price. The quality of any hay is also far from easy to evaluate, but quality is of special interest to dairy farmers. Hay producers, on the other hand, want to obtain a fair price for their best hay.

HAY GRADING

The old U.S. hay grades were based on how it looked. A recent U.S. Hay Marketing Task Force, however, proposed some new hay grading standards (Rohweder et al. 1976). The task force used information on (1) stage of maturity when harvested, (2) visual appearance, (3) chemical analysis, and (4) amount of hay consumed by animals in establishing the new grades. Separate grading systems were established for legume forage (Table 1) and grass forage (Table 2). When the hay is mixed grass and legume, the two grading systems have to be coordinated and adjusted. If the hay is predominantly legume, however, Table 1 would apply. If it is predominantly grass, Table 2 can be used.

Dry matter, crude protein, and acid detergent fiber (ADF) determinations were found from animal nutrition research to be the most reliable of the simple chemical methods presently being used to measure the nutritive value of feeds. The ADF measurement indicates the amount of fibrous matter of the forage. Increasing ADF means reduced nutritive value because of lowered energy digestibility. These analyses were featured on the laboratory analysis request form (Figure 1) that was developed for use by anyone who wanted hay analyzed. The cost per sample for the three analyses is $7.50 at the present time. Mineral analyses are provided at additional cost if specially requested. The USU feed analysis service can also be used to determine nutritive value of silages and other feedstuffs. Analysis request forms are available from the County Agriculture Extension Agent or the USU Soil, Plant, and Water Analysis Laboratory.

ESTIMATING RELATIVE VALUE

The results from several years of research (Anderson et al. 1973 and 1975) on factors affecting the quality of alfalfa hay were used to generate equations for predicting digestible energy from the crude protein and ADF content of alfalfa hay. Using the digestible energy of grade number 2 alfalfa hay (18% CP and 33% ADF) as the standard, a table of relative values was generated (Table 3).

A similar table for estimating the relative value of grass hay was generated from grass hay research (Christiansen et al. 1978) (Table 4). The relative value factors from Tables 3 and 4 represent equivalent digestible energy value. In other words, a grass hay having a relative value of, say, 1.00 would have the same digestible energy as an alfalfa hay having a relative value of 1.00. Special feeding situations may dictate use of grass hay to limit nutrient intake and justify giving grass hay a higher value.

Note that the crude protein and ADF content of a hay sample often lies outside the ranges defined by the standard grades in Tables 1 and 2. To include all probable crude protein and ADF analyses, the grades in Tables 3

TABLE 1. Proposed market grades for legume hay (USA Hay Marketing Task Force)

		Description				Typical Composition (dry basis)	
Grade	Stage of Maturity	Leaves %	Color	Foreign Matter %	Dust, mold, odor	Protein %	ADF[a] %
1	Late vegetative bud to first flower	40–50	Green	0–5	OK	>19	<31
2	Early bloom Initiation of bloom to 1/2 bloom	35-40	Light Green	<10	OK	17–19	31–35
3	Mid bloom (mid to full bloom); more than 1/2 bloom	25–40	Yellowgreen to Green	<15	OK	13–16	36-41
4	Full bloom (full and beyond)	<30	Brown to Green	<20	Slight	<13	>41
6	Contains toxic weeds or hardward, or has bad odor, or is heat damaged, hot, wet, musty moldy, badly weathered, dusty, extremely overripe, or contains more than 20% foreign material or less than 80% dry matter.						

[a]Acid detergent fiber (a measure of fibrous and indigestible matter)

Figure 1.

FEED ANALYSIS REQUEST

SOIL, PLANT AND WATER ANALYSIS LABORATORY
UMC 48 Utah State University
Logan, Utah 84322

Name: ____________________

Address: ____________________

____

Telephone Number: ____________________

County: ____________________

County Agent: ____________________

Date sampled: ____________________

Sample No. __________ Date Received __________

Analyses Desired	Report Oven-Dry	As-Received
☐ Moisture	0.00%	____%
☐ Ash	____%	____%
☐ Crude protein	____%	____%
☐ Acid detergent fiber (ADF)	____%	____%
☐ Calcium	____%	____%
☐ Phosphorous	____%	____%
Write in other analyses		
____________	____%	____%
____________	____%	____%

SAMPLE DESCRIPTION: Circle or check the word or words in each list that apply to this sample. If hay is a mixture of plants, indicate the approximate percentages of each forage plant. Add words to lists if necessary. Check only the descriptions that are known.

Original plant
- ☐ Alfalfa
- ☐ Alf ___% Grass ___%
- ☐ Alf ___% Weeds ___%
- ☐ Barley
- ☐ Oats
- ☐ Sorghum
- ☐ Wheat
- ☐ Beet
- ☐ Corn
- ☐ Cotton
- ☐ Bromegrass
- ☐ Orchardgrass
- ☐ Meadow
- ☐ __________ Other Plants

List of part fed
- ☐ Hay
- ☐ Silage
- ☐ Bran
- ☐ Grain
- ☐ Hay
- ☐ Screenings
- ☐ Straw
- ☐ Pulp
- ☐ Tops
- ☐ Cobs
- ☐ Ears
- ☐ Grain
- ☐ Stover
- ☐ Whole
- ☐ Meal
- ☐ Seeds
- ☐ Hay
- ☐ __________ Other Parts

List of processes before feeding
- ☐ Baled
- ☐ Cubed
- ☐ Dehydrated
- ☐ Ensiled
- ☐ Fresh
- ☐ Frost damaged
- ☐ Ground
- ☐ Molded
- ☐ Pelleted
- ☐ Rain damaged
- ☐ Rolled
- ☐ Solv-extd
- ☐ Sun-cured
- ☐ Wet
- ☐ Wilted
- ☐ __________ Other Processes

Stage of maturity (applies to forages and silages)
- ☐ Early vegetative (fresh new growth, immature, prebud stage)
- ☐ Late vegetative (first bud to first flower, grass heads in boot)
- ☐ Early bloom (less than 1/10 bloom; grasses heading out)
- ☐ Mid-bloom (1/10 to 2/3 bloom grass heads pollenating
- ☐ Full bloom (3/4 to full bloom; grass heads have dropped pollen)
- ☐ Late bloom (blossoms begin to dry, seeds begin to form)
- ☐ Milk stage (seeds are formed but soft and immature)
- ☐ Dough stage (seeds are of dough-like consistency)
- ☐ Mature (seeds are dry enough to harvest)
- ☐ Post ripe (seeds are ripe, plants have dried, beginning to weather)
- ☐ Stem cured (seeds have been case and plants weathered)
- ☐ Regrowth early vegetative (aftermath or 2nd cutting of grasses, regrowth after dry season

Cutting or crop: 1 2 3 4

A copy of this report will be returned to the customer, county agent and International Feedstuffs Institute **USU Form No. F-1**

TABLE 2. Proposed market hay grades for grass hay (USA Hay Marketing Task Force)							
		Description				Typical Composition (dry basis)	
Grade	Stage of Maturity	Leaves %	Color	Foreign Matter %	Dust, mold, odor	Protein %	ADF %
2	Late vegetative grass heads in boot	>50	Green	<5	OK	>18	<33
3	Early head (early bloom) less than 1/2 headed	>40	Light Green to Green	<10	OK	13–18	33–38
4	Headed (late bloom) seeds begin to form	>30	Yellowgreen to Green	<15	Slight	8–12	39–41
5	Post head (dough stage) seeds are well formed but still soft.	>20	Brown to Green	<20	Slight	<8	>41
6	Contains toxic or noxious weeds, has objectionable odor, heat damaged, wet, moldy or badly weathered.						

TABLE 3. Grade and Relative Value of Alfalfa Hay Estimated from Crude Protein and ADF (dry basis)

	Acid detergent fiber, %										
Crude Protein %	24	26	28	30	32	34	36	38	40	42	44
	Value factors										
24	1.160	1.145	1.131	1.116	1.101	1.086	--	--	--	--	--
23	1.145	1.130	1.115	1.100	1.086	1.071	1.056	--	--	--	--
22	1.130	1.115	1.100	1.085	1.070	1.056	1.041	1.026	--	--	--
21	1.115	1.100	1.085	1.070	1.055	1.040	1.026	1.011	.996	--	--
20	1.100	1.085	1.070	1.055	1.040	1.025	1.010	.996	.981	.966	--
19	--	1.070	1.055	1.040	1.025	1.010	.995	.980	.966	.951	.936
18	--	--	1.040	1.025	1.010	.995	.980	.965	.950	.936	.921
17	--	--	--	1.010	.995	.980	.965	.950	.935	.920	.906
16	--	--	--	.995	.980	.965	.950	.935	.920	.905	.890
15	--	--	--	--	.965	.950	.935	.920	.905	.390	.875
14	--	--	--	--	--	.935	.920	.905	.890	.875	.860
13	--	--	--	--	--	.920	.905	.890	.875	.860	.845
12	--	--	--	--	--	--	.890	.375	.860	.845	.830
11	--	--	--	--	--	--	--	.860	.845	.830	.815
10	--	--	--	--	--	--	--	.844	.830	.815	.800

Hay grades: 1=no.1 dairy; 2=no.2 feeder; 3=no.3 feeder; 4=no.4 feeder

TABLE 4. Grade and Relative Value of Grass Hay According to Crude Protein and ADF Content (dry basis)

	Acid detergent fiber, %										
Crude Protein %	28	30	32	34	36	38	40	42	44	46	48
	Value factors										
20	1.040	1.029	1.019	1.008	.997	.986	--	--	--	--	--
19	1.020	1.009	.998	.987	.976	.966	.955	--	--	--	--
18	.999	.988	.977	.967	.956	.945	.934	--	--	--	--
17	.979	.968	.957	.946	.935	.924	.914	.903	--	--	--
16	.958	.947	.936	.925	.915	.904	.893	.882	.871	--	--
15	.937	.927	.916	.905	.894	.883	.872	.864	.851	--	--
14	.917	.906	.895	.884	.873	.863	.852	.841	.830	.319	--
13	--	.886	.875	.864	.853	.842	.831	.820	.810	.799	--
12	--	--	.854	.843	.832	.822	.811	.800	.789	.778	.767
11	--	--	--	.823	.812	.801	.790	.779	.768	.758	.747
10	--	--	--	--	.791	.780	.770	.759	.748	.737	.726
9	--	--	--	--	--	.760	.749	.738	.727	.716	.706
8	--	--	--	--	--	.739	.729	.718	.707	.696	.685
7	--	--	--	--	--	--	.708	.697	.686	.675	.665
6	--	--	--	--	--	--	.687	.676	.666	.655	.644
5	--	--	--	--	--	--	--	.656	.645	.634	.623
4	--	--	--	--	--	--	--	.635	.625	.614	.603

Hay grades: 2=no.2 dairy; 3=no.3 feeder; 4=no.4 feeder; 5=no.5 feeder

TABLE 5. Dry Matter adjustment for feeds[a]

% Dry Matter:	85	86	87	88	89	90	91	92	93
Adjustment factor:	.944	.956	.967	.978	.989	1.00	1.01	1.02	1.03

[a]Less than 85% dry matter is in danger of molding

and 4 are extended to areas having similar nutritive value.

To estimate the relative value of alfalfa hay with the crude protein and ADF analysis, find the intersection of the protein line and ADF column in Table 3. Use the analysis on the 100% dry basis. This value is then adjusted for the dry matter content of the hay.

DRY MATTER ADJUSTMENT

Field dried hay is baled before it is completely air dry (less than 85% dry matter) to avoid loss of leaves and produce compact bales. These bales still dry to about 90% dry matter in the stack. The dry matter value of the hay is used to correct the field dried hay to an average of 90% air dry matter for baled hay in a sheltered stack. Drier hay is worth more since water contributes no nutritive value. Table 5 converts the determined dry matter of the hay to a dry matter adjustment factor (or divide the dry matter % of the sample by 90%).

ESTIMATING MARKET VALUE

The Federal-State Market News Service reports the selling price of alfalfa hay each week as sufficient market information is available. Few news media publish this portion of the farm market news. This weekly market report can be obtained by individuals upon request from The Federal-State Market News, North Salt Lake Stock Yards, North Salt Lake, Utah 84054. Instant market news can be obtained by telephone (801-524-5001) at any time of the day or night. The market value will vary for different locations with supply and demand and transportation and handling costs.

To estimate the market value of a hay sample, multiply the current market price for number 2 hay by the value factor from Tables 3 or 4 and the dry matter adjustment factor from Table 5.

For example: Suppose a laboratory report described an alfalfa hay sample as containing 15% protein, 38% ADF, and 92% dry matter. The hay appeared stemmy but was green. Suppose the market price for number 2 alfalfa hay at that time was $60 per ton. The quality factor from Table 3 is .920 and the dry matter adjustment from Table 5 is 1.022 (or 92% ÷ 90% = 1.022). The value of the hay can thus be calculated as $60 × .920 × 1.022 or $56.41 per ton. Transportation and handling costs will further vary the value of hay from one location to another.

FEED DESCRIPTION

The checklist of words for describing a feed that is included on the analysis request form (Figure 1) helps farmers to record the description of the particular lot of feed analyzed with the chemical analysis. These laboratory reports can be a basis for comparing the nutritive values of the various feeds they produce from season to season. Farmers can then learn how to improve the quality of farm grown feeds.

The more exactly a feed is described, the more likely it will be similar to the same feed produced the same way on other land or in another year.

For example, hay is the common name for the aerial parts of forage plants harvested and dried for livestock feed. When we add the word alfalfa, the hay is limited to a specific plant. By further specifying the process (sun-cured, baled), stage of maturity (early bloom), and cutting (cut 2), we describe one of the numerous (100 to 150) possible combinations that qualify as alfalfa hay. The descriptive terms represent factors that influence the nutritive value of the feed. Samples qualifying for the same feed description, though from different locations and growing seasons, are likely to have similar nutritive values.

Feed information is also identified by where the material was grown (country, state, and county). As sufficient information becomes available from various locations for specific feeds, it may be possible to determine if some places can grow higher quality feed than others.

GENERATING FEED INFORMATION

When those who request an analysis include a complete sample description, they move us closer to being able to summarize feed analysis information for their particular area and subsequently the production and publication of feed composition tables. The average values listed in such tables would allow them to compare quality of feeds grown in that area. The feed nutrient information generated in Utah during 1978 and 1979 is summarized in Table 6.

The quality of the information in Table 6 depends greatly on the farmer or sampler obtaining a representative sample, preserving the original quality of the sample by proper packaging and rapid transportation to the laboratory (especially important for high moisture feeds). The feed descriptions used in Table 6 were supplied by the farmer.

Information generated over the first two years shows that farmers can and will provide a detailed description of the feed sample if a convenient form is provided. Table 6 summarizes information for 67 feeds (40 dry forages, 19 silages, 3 fresh feeds, and 5 energy feeds) obtained from 425 samples. (1) The number of observations for each feed nutrient, (2) the "as fed dry matter" and analysis, and (3) the analysis on the 100% dry matter basis are shown. As more farmers identify the processes, stage of maturity and cutting of the feed samples sent for analysis the information for specific feeds will be more complete.

REQUESTING OTHER ANALYSES

Analysis for the nutrient minerals can also be requested for crops grown on particular land of the farm. Calcium, copper, iron, magnesium, manganese, phosphorus, potassium, selenium, sulfur, and zinc are essential for animal production. Mineral supplements are frequently used without knowing whether real deficiencies in the feedstuffs are present. Mineral deficiencies can also be present in the feeds that, if known, can be corrected by proper supplementation of the animal diet.

SUMMARY

A feed analysis service is being offered by the Soil, Plant, and Water Analysis Laboratory of Utah State University. During 1978 and 1979 about 425 adequately described feed samples (including 67 distinct feeds with 38 variations of alfalfa) were analyzed. A system has been developed to estimate hay quality from chemical analyses. The analytical information from these analyses was summarized in a table of feed composition for Utah-produced crops in 1978.

PHOTOS AT RIGHT:

Dr. Fonnesbeck takes a hay sample with a Penn State Forage Sampling Tool (1,2,3). In the lab, the sample is ground to a coarse powder, measured (4), and boiled in acid detergent solution (5), which yields the AD Fiber (6). Samples are then reported and logged by technicians (7). In general, a higher fiber content indicates a lower quality hay.

Photos by Mike Jackson

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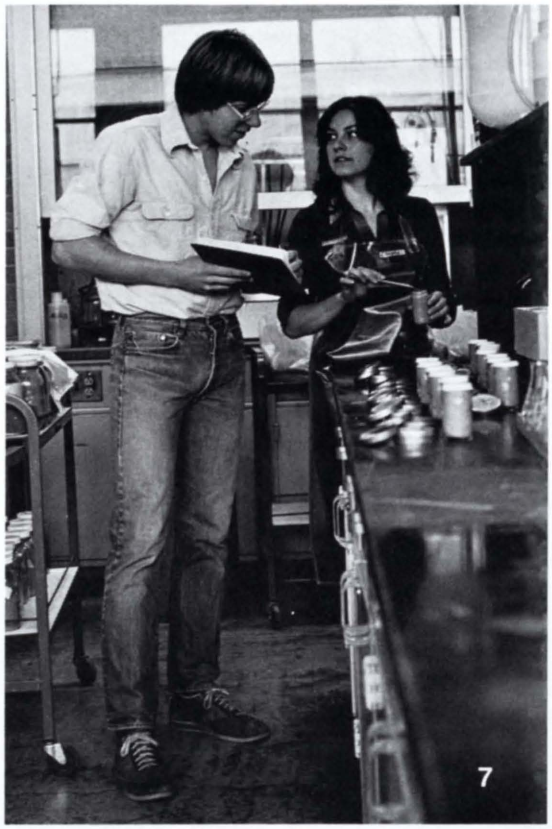

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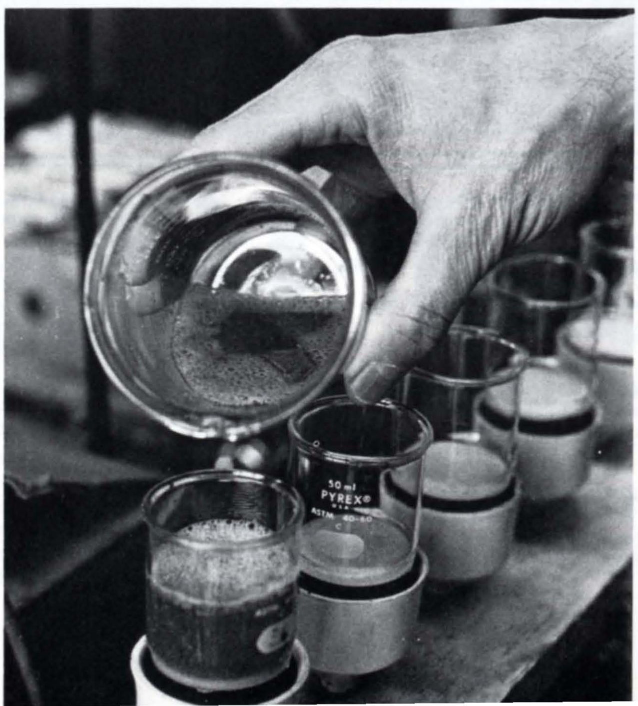

TABLE 6. Number of Samples Analyzed and Composition of Utah Feeds (1978-79 Crop)

Line No.	Feed Name and International Feed Number	Item	Dry Matter %	Crude Protein %	Acid Detergent Fiber %
	ALFALFA				
001	- hay, sun-cured	No. Obs.	67	95	94
002	1-00-078	As Fed	90.1	16.9	30.8
003		Dry	100.0	18.8	34.2
004	- hay, sun-cured, late	No. Obs.	9	8	9
005	vegetative	As Fed	91.0	17.4	27.5
006	1-00-054	Dry	100.0	19.1	30.2
007	- hay, sun-cured, late	No. Obs.	22	22	22
008	vegetative, cut 1	As Fed	91.1	17.5	27.4
009	1-00-051	Dry	100.0	19.2	30.1
010	- hay, sun-cured, late	No. Obs.	17	17	17
011	vegetative, cut 2	As Fed	91.6	18.4	30.1
012	1-00-052	Dry	100.0	20.1	32.9
013	- hay, sun-cured, late	No. Obs.	8	8	8
014	vegetative, cut 3	As Fed	89.5	18.5	28.0
015	1-00-053	Dry	100.00	20.7	31.3
016	- hay, sun-cured, late	No. Obs.	1	1	1
017	vegetative, cut 4	As Fed	88.5	21.3	20.9
018	1-20-693	Dry	100.0	24.1	23.6
019	- hay, sun-cured,	No. Obs.	17	18	16
020	early bloom	As Fed	90.5	16.8	27.7
021	1-00-059	Dry	100.0	18.6	30.6
022	- hay, sun-cured,	No. Obs.	35	35	34
023	early bloom, cut 1	As Fed	91.3	16.9	29.2
024	1-00-055	Dry	100.0	18.5	32.0
025	- hay, sun-cured,	No. Obs.	12	12	10
026	early bloom, cut 2	As Fed	91.1	18.1	30.2
027	1-00-056	Dry	100.0	19.9	33.2
028	- hay, sun-cured,	No. Obs.	17	17	14
029	early bloom, cut 3	As Fed	89.8	18.7	25.6
030	1-00-057	Dry	100.0	20.8	28.5
031	- hay, sun-cured,	No. Obs.	13	12	8
032	midbloom	As Fed	91.3	16.6	31.4
033	1-00-063	Dry	100.0	18.1	34.5
034	- hay, sun-cured,	No. Obs.	16	16	16
035	midbloom, cut 1	As Fed	90.5	15.8	29.8
036	1-00-060	Dry	100.0	17.5	32.9
037	- hay, sun-cured,	No. Obs.	10	11	11
038	midbloom, cut 2	As Fed	91.4	17.5	31.8
039	1-00-061	Dry	100.0	19.2	34.8
040	- hay, sun-cured,	No. Obs.	7	7	7
041	midbloom, cut 3	As Fed	89.4	17.7	27.4
042	1-00-062	Dry	100.0	19.8	30.7
043	- hay, sun-cured,	No. Obs.	2	2	2
044	midbloom, cut 4	As Fed	95.7	18.0	30.7
045	1-30-209	Dry	100.0	18.8	32.1
046	- hay, sun-cured,	No. Obs.	2	2	2
047	full bloom	As Fed	92.7	14.4	40.8
048	1-00-068	Dry	100.0	15.6	44.0
049	- hay, sun-cured,	No. Obs.	2	2	2
050	full bloom, cut 1	As Fed	91.1	15.6	30.7
051	1-00-064	Dry	100.0	17.1	33.7
052	- hay, sun-cured,	No. Obs.	2	2	2
053	full bloom, cut 2	As Fed	89.7	15.5	33.0
054	1-00-065	Dry	100.0	17.3	36.8
055	- hay, sun-cured,	No. Obs.	28	26	24
056	cut 1	As Fed	90.2	16.4	27.6
057	1-00-073	Dry	100.0	18.2	30.6
058	- hay, sun-cured,	No. Obs.	6	8	8
059	cut, 2	As Fed	91.9	17.4	28.3
060	1-00-075	Dry	--	--	--
061	- hay, sun-cured,	No. Obs.	3	5	4
062	cut 3	As Fed	91.7	17.5	28.7
063	1-00-076	Dry	100.0	19.1	31.3
064	- hay, sun-cured,	No. Ob.s	2	2	3
065	cut 4	As Fed	89.2	16.2	35.5
066	1-00-077	Dry	100.0	18.2	39.8
067	- hay, sun-cured cubed,	No. Obs.	2	2	2
068	cut 2	As Fed	90.6	16.4	32.3
069	1-26-210	Dry	100.0	18.1	35.7
070	- hay, sun-cured cubed,	No. Obs.	2	2	2
071	early bloom, cut 3	As Fed	89.0	16.5	26.9
072	1-30-217	Dry	100.0	18.6	30.2
073	- hay, sun-cured rained on	No. Obs.	1	1	1
074	cubed, early bloom, cut 1	As Fed	92.3	16.0	32.8
075	1-30-216	Dry	100.0	17.3	35.5
076	- hay, sun-cured rained on	No. Obs.	1	1	1
077	cubed, early bloom, cut 2	As Fed	91.3	17.6	33.7
078	1-30-218	Dry	100.0	19.3	36.9
079	- hay, sun-cured	No. Obs.	1	1	1
080	wafered	As Fed	93.3	19.1	26.3
081	1-07-746	Dry	100.0	20.5	28.2
082	- hay, sun-cured wafered,	No. Obs.	2	2	2
083	late vegetative, cut 1	As Fed	90.3	17.3	27.6
084	1-22-435	Dry	100.0	19.2	30.5
085	- hay, sun-cured wafered,	No. Obs.	1	1	1
086	late vegetative, cut 2	As Fed	90.7	19.1	26.6
087	1-20-248	Dry	100.0	21.1	29.3
088	- hay, fresh, early bloom,	No. Obs.	--	1	1
089	cut 1	As Fed	--	--	--
090	2-00-182	Dry	100.0	15.1	38.0
091	- hay, silage, late vegetative	No. Obs.	--	1	1
092	3-00-204	As Fed	--	--	--
093		Dry	100.0	20.6	50.5
094	- hay, silage, early bloom,	No. Obs.	--	1	1
095	cut 1	As Fed	--	--	--
096	3-07-844	Dry	100.0	18.4	33.2
097	- hay, silage, early bloom,	No. Obs.	1	1	1
098	cut 3	As Fed	65.9	12.7	23.9
099	3-07-903	Dry	100.0	19.3	36.3
100	- hay, silage, midbloom,	No. Obs.	1	1	1
101	cut 2	As Fed	69.2	11.8	16.3
102	3-30-220	Dry	100.0	17.1	23.6
103	- hay, silage, full bloom	No. Obs.	1	1	1
104	3-00-207	As Fed	22.5	4.5	8.5
105		Dry	100.0	20.1	37.6
106	- hay, silage, less than 30%	No. Obs.	2	2	1
107	dry matter	As Fed	25.0	4.2	11.8
108	3-08-149	Dry	100.0	16.9	42.3
109	- hay, silage, 30-50% dry	No. Obs.	3	4	3
110	matter	As Fed	44.6	9.0	16.4
111	3-08-150	Dry	100.0	20.3	36.8
112	- hay, silage, more than	No. Obs.	1	1	1
113	50% dry matter	As Fed	62.5	10.3	28.8
114	3-08-151	Dry	100.0	16.4	46.1
115	- hay, wilted silage	No. Obs.	1	1	1
116	3-00-221	As Fed	42.8	9.0	11.1
117		Dry	100.0	21.0	25.9
118	- hay, wilted silage, early	No. Obs.	1	1	1
119	bloom	As Fed	30.5	5.3	12.1
120	3-00-216	Dry	100.0	17.5	39.6
121	- hay, wilted silage, early	No. Obs.	1	1	1
122	bloom, cut 3	As Fed	27.6	4.8	11.7
123	3-21-895	Dry	100.0	17.4	42.4
	ALFALFA-GRASS				
124	- hay, sun-cured	No. Obs.	2	2	2
125	1-08-331	As Fed	92.2	13.5	34.0
126		Dry	100.0	14.7	36.9
127	- hay, sun-cured, early	No. Obs.	3	3	3
128	bloom	As Fed	90.2	16.3	28.0
129	1-00-296	Dry	100.0	18.0	31.0
130	- hay, sun-cured, midbloom	No. Obs.	1	1	1
131	1-00-297	As Fed	86.3	13.5	27.2
132		Dry	100.0	15.6	31.5
133	- hay, sun-cured, cut 1	No. Obs.	6	6	6
134	1-00-299	As Fed	91.9	14.2	30.6
135		Dry	100.0	15.4	33.3
136	- hay, sun-cured, cut 2	No. Obs.	1	1	1
137	1-00-300	As Fed	90.5	13.8	30.1
138		Dry	100.0	15.2	33.3
	BARLEY				
139	- forage, silage, dough stage	No. Obs.	1	1	--
140	3-20-246	As Fed	37.0	3.0	--
141		Dry	100.0	8.1	--
142	- forage, grain	No. Obs.	9	9	4
143	4-00-549	As Fed	89.0	11.0	11.1
144		Dry	100.0	12.4	12.4
	BEET, SUGAR				
145	- tops with crowns, silage	No. Obs.	1	1	--
146	3-00-660	As Fed	33.9	4.7	--
147		Dry	100.0	13.9	--
148	- pulp, dehy	No. Obs.	1	1	1
149	4-00-669	As Fed	93.8	10.9	17.7
150		Dry	100.0	11.6	18.9
	GRASS				
151	- hay, sun-cured, dough	No. Obs.	1	1	1
152	stage	As Fed	83.8	6.0	35.1
153	1-20-753	Dry	100.0	7.2	41.9
	CORN				
151	- silage	No. Obs.	2	3	3
152	3-02-822	As Fed	28.4	2.2	9.2
153		Dry	100.0	7.8	32.6
154	- silage, milk stage	No. Obs.	1	1	1
155	3-02-818	As Fed	26.2	1.9	9.7
156		Dry	100.0	7.3	37.0
157	- silage, dough stage	No. Obs.	3	5	4
158	3-02-819	As Fed	27.7	2.4	8.9
159		Dry	100.0	8.8	32.1
160	- silage, mature	No. Obs.	1	1	1
161	3-02-820	As Fed	27.6	1.9	8.4
162		Dry	100.0	6.9	30.4
163	- silage, less than 30%	No. Obs.	8	8	2
164	dry matter	As Fed	27.2	2.4	9.7
165	3-20-507	Dry	100.0	8.7	35.9
166	- silage, 30-50% dry matter	No. Obs.	2	1	1
167	3-20-506	As Fed	44.3	4.0	13.2
168		Dry	100.0	9.1	29.8
169	- grain, silage	No. Obs.	--	2	--
170	4-07-739	As Fed	--	--	--
171		Dry	100.0	11.2	--
172	- grain, moldy	No. Obs.	2	2	--
173	4-26-127	As Fed	84.4	9.3	--
174		Dry	100.0	11.0	--
	CORN-SORGHUM				
175	- silage, mature	No. Obs.	2	2	2
176	3-03-013	As Fed	30.0	2.4	10.0
177		Dry	100.0	7.9	33.2
	GRASS				
178	- hay, sun-cured, dough	No. Obs.	1	1	1
179	stage	As Fed	83.8	6.0	35.1
180	1-20-753	Dry	100.0	7.2	41.9
	MEADOW PLANTS, INTERMOUNTAIN				
181	- hay, sun-cured	No. Obs.	1	1	--
182	1-03-181	As Fed	93.7	6.5	--
183		Dry	100.0	6.9	--
184	- hay, sun-cured, late bloom,	No. Obs.	2	2	2
185	cut 1	As Fed	93.7	7.6	35.2
186	1-09-176	Dry	100.0	8.1	37.6
187	- hay, sun-cured, cut 1	No. Obs.	1	1	1
188	1-23-463	As Fed	94.8	8.6	35.5
189		Dry	100.0	9.1	37.4
190	- hay, sun-cured, mature	No. Obs.	1	1	--
191	1-08-465	As Fed	92.7	4.0	--
192		Dry	100.0	4.3	--
	OATS				
193	- hay, sun-cured	No. Obs.	1	1	1
194	1-03-280	As Fed	93.7	11.3	36.0
195		Dry	100.0	12.1	38.4
	OATS-ALFALFA				
196	- forage, silage	No. Obs.	1	1	1
197	3-29-773	As Fed	45.5	4.5	23.1
198		Dry	100.0	9.9	50.7
	ONION, GARDEN				
199	- bulbs, fresh, mature	No. Obs.	1	1	--
200	4-03-418	As Fed	10.3	1.0	--
201		Dry	100.0	10.1	--

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LARKSPURS

A DEADLY BEAUTY

EUGENE H. CRONIN and DARWIN B. NIELSEN

CULTIVATED LARKSPURS (THE DELPHINIUM) adorn the flower gardens of the world. Native species blanket our western rangelands in blue and purple; a poisonous beauty. Rangeland larkspurs have been a source of heavy economic losses ever since the livestock industry migrated West in the 1800s. These have often proved to be catastrophic for individual stockmen...spiralling to an estimated annual total industry loss of millions of dollars.

Benefits

Long known to be poisonous, larkspur were used by the ancient herbalists of Greece and Rome as medicinal plants. A tincture of larkspur seed was suggested for the destruction of lice and mites in the hair, while the juice from larkspur was advocated as a remedy for colic, dropsy, spasmodic asthma, and as a purgative. In modern times, scientists have reported that various species of larkspur contain curare-like compounds, dyes, and even insecticides that could be used to control locusts, grasshoppers, maggots, and ticks.

Drawbacks

Recently, greater attention has been focused on the larkspurs of our western rangelands. Our rapidly increasing population has brought an increasing demand for red meat, but the stockmen's profit margin has dwindled to the point where they are no longer able to accept the five percent loss of grazing animals that was once thought to be normal and acceptable. Our growing population has also increased the need for land for non-agricultural uses, which has reduced the amount of land available for red meat production. While it was once possible to move livestock from poison-infested areas to alternative areas, today ranchers may not have that option and must find other management strategies and solutions.

Manti Canyon problem

Stockmen in the Manti Canyon Cattlemen's Association were confronted with this dilemma in the late 1950s. These stockmen have permits to graze about 850 cattle from June to October each year on a U.S. Forest Service grazing allotment on the Manti Canyon drainage of the Wasatch Plateau in central Utah. The Manti Canyon Cattle Allotment contains about 20,000 acres. In 1958, these cattlemen lost 103 cows or 12 percent of their herd while the animals were grazing on the subalpine portion of the allotment. Records of losses during the period of 1956 through 1970 indicated an average loss of 36 cows each year. (The current average market value of a cow is $500.)

The subalpine zone on the allotment covers about 8,000 acres and contains numerous patches of barbey larkspur (*Delphinium barbeyi*), which is the most toxic species of larkspur. A survey conducted in 1960 indicated that only about 344 acres in the subalpine zone were infested with barbey larkspur which, while it represented only about one percent of the allotment, was cutting deeply into their profits and threatening the stockmen's ability to continue in the livestock business. The only alternative grazing areas available to them were their hay fields; however, they were dependent on these hay fields to produce the fodder required to carry their cattle through the six months of winter when snow cover prevents grazing.

Initiating a solution

The officers of the association wrote letters to the U.S. Department of Agriculture and to the Utah Agricultural Experiment Station of Utah State University urgently requesting research on their problem. Both organizations recognized the seriousness of the problem and that it was common throughout Utah and other western states. The USDA assigned a plant specialist to investigate methods of controlling the poisonous plants. The experiment station assigned an agricultural economist to evaluate the impact of the losses on beef production and the economics of various methods of controlling the losses. Although employed by different research organizations, both individuals recognized that a solution to the problem could only be reached by combining their knowledge and resources. The U.S. Forest Service also recognized the importance and widespread nature of the problem and provided exemplary cooperation and materials to support the research effort.

While Manti Canyon was selected as the main site for research, the investigations eventually included sites near Cedar City, Logan, Randolph, and Snowville in Utah as well as a site near Dubois, Idaho.

The major larkspur groups

Larkspurs are readily separated into two major groups, the low larkspurs and the tall larkspurs. The low larkspurs are, generally, less than 61 cm (2 ft) tall while the tall larkspurs grow to over 91 cm (3 ft) each year. Differences between the two groups are, however, not confined to simple morphological features. They have different growth habits, they respond differently to herbicide treatments, and they cause livestock losses in different types of vegetation. The differences in the two groups require that they be viewed and treated as two different problems.

THE LOW LARKSPURS

Losses due to the low larkspurs are periodic and usually occur on grazing areas at lower elevations (4,000 to 7,000 ft in Utah) used for spring grazing. Here the low larkspurs are among the earliest producers of green herbage each spring, and it is during this period that grazing animals are most likely to ingest lethal levels of them. Plants in this group grow rapidly and complete their annual growth cycle while the soil moisture is abundant. When soil moisture becomes limited the low larkspurs dry and disappear from the vegetation. While livestock losses to the low larkspurs are periodic and are reported infrequently, they can be severe under such conditions as when the snow cover melts early and low temperatures inhibit production of forage plants. However, some heavy losses to the low larkspur have occurred when abundant forage was available.

Two species of low larkspur, **nelson larkspur** (*D. nelsonii*) and **anderson larkspur** (*D. andersonii*), cause most of the livestock losses in Utah. Nelson larkspur is found in most of Utah from elevations of 4,000 to over 10,000 ft. Anderson larkspur is limited to Box Elder, Tooele, Juab, and Piute counties and appears to be restricted to elevations of 4,000 to 6,000 ft. Both are perennials and appear to be long lived. Their ecology has received little attention from researchers, but they are probably climax species that are able to grow in many stages of vegetational development.

Losses to the low larkspurs are very difficult to document because they are, for the most part, small and appear to be restricted to cattle. Unless the losses are unusually large they are not reported. However, reports coming into the Poisonous Plant Research Laboratory suggest that these losses are important and annual in occurrence.

Research on the control of the low larkspur has been limited to the nelson larkspur. They can be controlled, but the economics of the control cannot be evaluated until more information is accumulated concerning their ecology and the losses that are incurred as a result of them. They do not respond to the herbicides that control the tall larkspurs, but there are a number of herbicide treatments that can be used to control them. The selection of the proper treatment depends on the type of vegetation on the sites where they are causing losses.

THE TALL LARKSPURS

The tall larkspurs grow in specific habitats on our high mountain ranges. They inhabit sites with deep soils where soil moisture is available over most or all of the growing season. They are most abundant on deep soils where snow accumulates and persists late in the growing season, around seeps or springs, and along the margins of streams.

Two species, **barbey larkspur** and **duncecap larkspur** (*D. occidentale*), are the source of most losses in Utah to the tall larkspurs. Barbey larkspur occurs south of an arbitrary line along the northern boundaries of Juab, Sanpete, and Carbon counties while duncecap larkspur generally inhabits the mountains to the north. They are both long-lived perennials and climax species.

Evidence of larkspurs' longevity and tenacity

Evidence from the Wasatch Plateau indicates the longevity and the tenacious persistence of established plants. Prior to the establishment of the Manti National Forest, the Wasatch Plateau was subjected to unrestricted grazing by numerous transitory herds of sheep. This abusive overgrazing resulted in the destruction of the vegetation on the plateau which brought devastating floods of water, mud, and rocks to the canyons, farmlands, and towns in the valleys. Barbey larkspur survived this unregulated period of abusive overgrazing. However, with the associated vegetation destroyed, the soil was eroded from between the larkspur plants leaving them growing on elevated hummocks. Knowledge of the period when the subalpine zone was subjected to severe erosion and observations of large robust plants growing on the hummocks gives evidence that the plants were established before the erosion occurred. It is logical to assume that the plants growing on these hummocks are 75 or more years old.

Barbey larkspur is as common sheep allotments as it is on cattle allotments on the Wasatch Plateau. On Cedar Mountain east of Cedar City, barbey larkspur continues to survive on bedgrounds used daily by sheep for 15 years or more. Sheep eat the leaves but not the stems, flowers, or seed pods. Apparently the photosynthetic tissues of the stem produce and store sufficient food to keep the plant functioning during the growing season and to initiate new growth the following spring. All of this points to sheep being an unlikely control for tall larkspurs.

The tall larkspurs remain green from the last frost in the spring to the first frost in the fall. The concentration of the poisonous alkaloids is highest in the new spring growth and slowly declines until the plants produce flowers, at which point it diminishes. However, new leaves, flower buds, flowers, and maturing seed always contain high concentrations of lethal alkaloids.

The toxicity of larkspur herbage is dependent on the parts of the plants which are ingested. Stems and mature leaves are relatively low in alkaloid content. This probably explains why few sheep losses occur, because sheep select the older, more mature leaves and ignore the more toxic young leaves unless the mature leaves have already been depleted. However, ranchers on Cedar Mountain where barbey larkspur constitutes a large portion of the sheep diet each fall, report that attempts to move sheep that have eaten large amounts of larkspur produce losses.

Cattle loss

Cattle consistently select the more toxic portions of the larkspur plants. They prefer young leaves, the flower buds, the flowers, and the seed pods as the seeds near maturity. Most cattle will utilize the tall larkspur casually as they pass close to a plant, but observations suggest that after ingesting a certain level of larkspur their grazing habits change. When this occurs, their utilization of larkspur increases and they ingest not only the normally preferred parts but also the large stems and older leaves. Evidence from a number of sources indicates that animals killed by larkspur had ingested many times a lethal dose.

Cattle losses on the Manti Canyon allotment appeared to be associated with large dense patches of larkspur found on sites where winter winds accumulated large deep snowdrifts that persisted from three weeks to two months after the snow had melted from the surrounding areas. Most of the dead animals were found between 100 and 300 yards below these large patches of larkspur.

It has generally been accepted that calf losses on grazing areas with large populations of larkspur are indirect and result from the deaths of their mothers. Evidence from studies in Manti Canyon, however, indicates that calf losses are the result of the calves ingesting lethal levels of larkspur. Three summers of intensive studies revealed no evidence to suggest that any of the dead calves had been orphans. Examination of the contents of their rumens indicated that they had recently ingested milk, and in many cases cows either returned repeatedly to or stood near dead calves for a number of hours. The source of larkspur for these dead calves appeared to be associated with small patches of larkspur growing in the many groves of coniferous trees scattered over the subalpine zone. On steep terrain cows typically leave their calves resting in these groves while they graze on the higher areas. In two instances it was possible to backtrack from dead calves to these intragrove larkspur patches where leaves had been stripped from the poisonous plants. Observations indicated that hungry calves frequently stripped leaves from larkspur plants.

Methods to reduce or prevent losses

Knowledge of the conditions and sites where losses occur suggest some management practices that could be used to reduce or prevent losses. Sheep losses can be prevented by being careful not to physically stress them immediately after they have ingested large quantities of larkspur. Reduction of cattle losses appears to require the removal of most of the larkspur plants in the large dense patches. It does not require eradication of these plants from grazing areas. The method used to

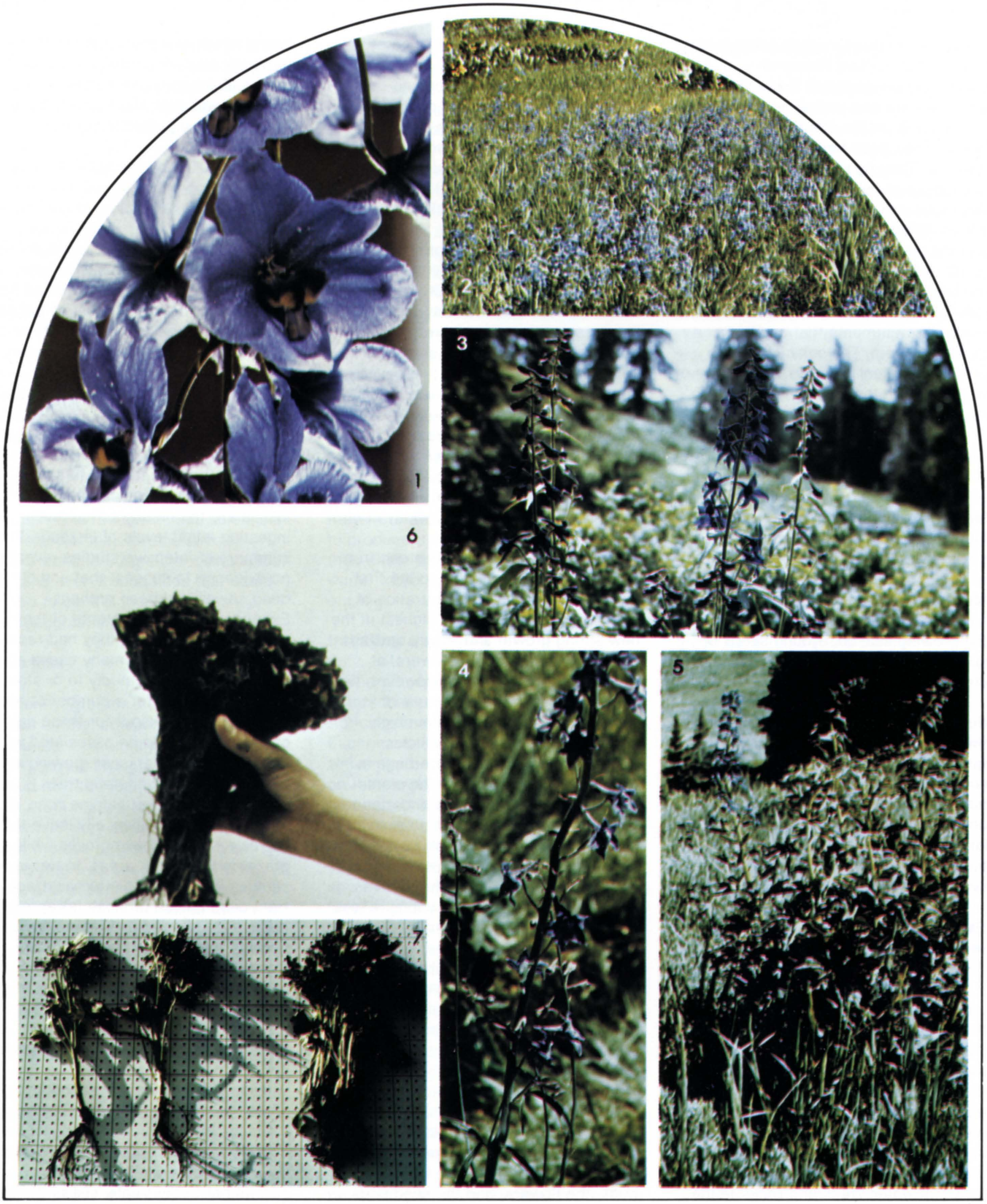


Photo by author

Figure 1. The showy flowers of the cultivated larkspurs assure their popularity in the flower gardens of the world.

Figure 2. Nelson larkspur, a low larkspur, grows in Utah and is a serious source of cattle losses during the early spring months.

Figure 3. The spur on the flowers of barbey larkspur originate near the center and tend to curve sharply downward at the tip.

Figure 4. The spur of duncecap larkspur tend to originate near the top and form a straight line with the top of the flower.

Figure 5. Barbey larkspur is a tall plant with many stems and abundant leaves.

Figure 6. The stout taproot of barbey larkspur. The large root crown indicates that it is 75 years old or older.

Figure 7. Duncecap larkspur tends to be a slender stemmed plant originating from a small root crown. The plant on the right is the largest plant observed.

reduce the population should, however, cost less than the value of the animals saved. Manipulation of the vegetation can be accomplished through grazing management, by mechanical methods, or by applying selective herbicides.

The vegetation existing on the Wasatch Plateau today is an example of the effectiveness of grazing management used to improve both the watershed properties and forage production. The people of the area, the state, and the nation should be grateful to both the U.S. Forest Service and the ranchers holding grazing permits for the outstanding job they have done in rehabilitating this critical watershed and vital grazing resource, although their efforts to improve the vegetation have also apparently increased the barbey larkspur, too.

Considerable knowledge of the life history of the larkspur is required if it is to be selectively removed by mechanical methods or by applications of selective herbicides. If it is selectively removed, would establishment of new plants occur immediately, requiring frequent treatments to keep the population below potentially dangerous levels?

Fortunately, studies of the life histories of barbey and duncecap larkspur revealed that although both species were prolific seed producers, the seed had a life expectancy of only one year. Germination rates for the seed are high, but survival rates for the seedlings are low. Mortality rates for established seedlings are also high. Even when seedlings become established and survive, they require three to eight years before they are mature enough to produce flowers. The results of these studies indicate that it would be many years before new plants invading treated areas would produce potentially dangerous quantities of herbage.

Grubbing is an effective mechanical method of selectively removing tall larkspur without destroying the associated vegetation required to protect the watershed. To be effective each plant must be grubbed out to a depth of 12 inches and the root must be dried or burned to prevent sprouting. However, it was not possible to find the labor necessary for this arduous task in the Manti area. Grubbing, if done on a large scale would probably be economical, but only marginally so.

Selective herbicide treatments offered the only feasible hope of reducing larkspur losses for beleaguered ranchers. An intensive study was initiated and followed for eight years to evaluate herbicide treatments. This long period was required because the vegetation had to be watched for four to five years to determine whether the poisonous larkspur or other equally undesirable species would reinvade the treated areas or that accelerated erosion would not occur after applications of the treatments.

The treatment selected from those evaluated as ecologically safe and effective was a treatment requiring two applications of four lb/acre of 2,4,5-T spaced one to two years apart. Both applications were required. This treatment removed the larkspur and many other weedy forbs, leaving the plots with a dense cover of grasses. However, it was learned that if cattle were to graze the plots immediately after the first application, the grasses would be dominated by the weedy and unpalatable letterman needle grass (*Stipa lettermani*) which was judged to be a poor watershed plant. Continuing research revealed that for best results cattle should not be allowed to graze treated areas until the grass seed were ready to shatter. Under these conditions the seed were knocked to the ground and the hooves of the grazing cattle pushed them into the soil. This resulted in a grass community dominated by the palatable mountain brome (*Bromus carinatus*).

Herbicide evaluation studies were carried out on small plots. The selected treatment had to be applied to a large area to determine (1) if the treatment of only the large, dense patches (rather than every site where larkspur was found) would reduce losses, (2) if the level of larkspur control achieved with treatment would reduce losses, (3) if the larkspur could be controlled without contamination of the numerous streams flowing through the subalpine zone, and (4) if the applications of the treatment would be economically feasible.

The 2,000 acre North Fork Grazing Unit was selected for this large-scale test. It was selected because records indicated that losses were especially severe in this unit. Applications of the treatment were started in 1969 but limited finances, restriction on the use of 2,4,5-T, and the need to coordinate the treatments with the grazing program still hamper the completion of the study. However, the treatments applied have reduced losses beyond expectations. By the end of the 1979 grazing season it was estimated that more than 90 cattle have been saved, with less than 70 percent of the total larkspur area treated.

Water samples collected from the streams during and after applications indicated that the levels of 2,4,5-T found never exceeded levels acceptable in drinking water. (Water in Manti Creek is not used for culinary purposes.)

Economic analysis of the North Fork study indicates a high rate of return for money invested in tall larkspur control.

The total cost of controlling tall larkspur on the high elevation Manti allotment is: *

first application:		
344 acres x $22/acre	=	$ 7,912
second application:		
344 acres x $17/acre	=	5,848
	Total	$13,760

The expected value of cattle saved each year if the larkspur is controlled is:

33 cows x $250/head	=	$ 8,250
10 calves x $120/head	=	1,200
	Total	$ 9,450

It is estimated that the control will remain effective in reducing losses for at least 10 years.

Based on these control costs and these expected annual returns ranchers would receive a return of about 60 percent on their invested money. This appears to be an exceptionally good return on invested capital and should encourage investment in control. In addition there would be $9,450 of new money in the Utah economy which would be multiplied two to four times in total economic activity as it moves through the economy.

ABOUT THE AUTHORS

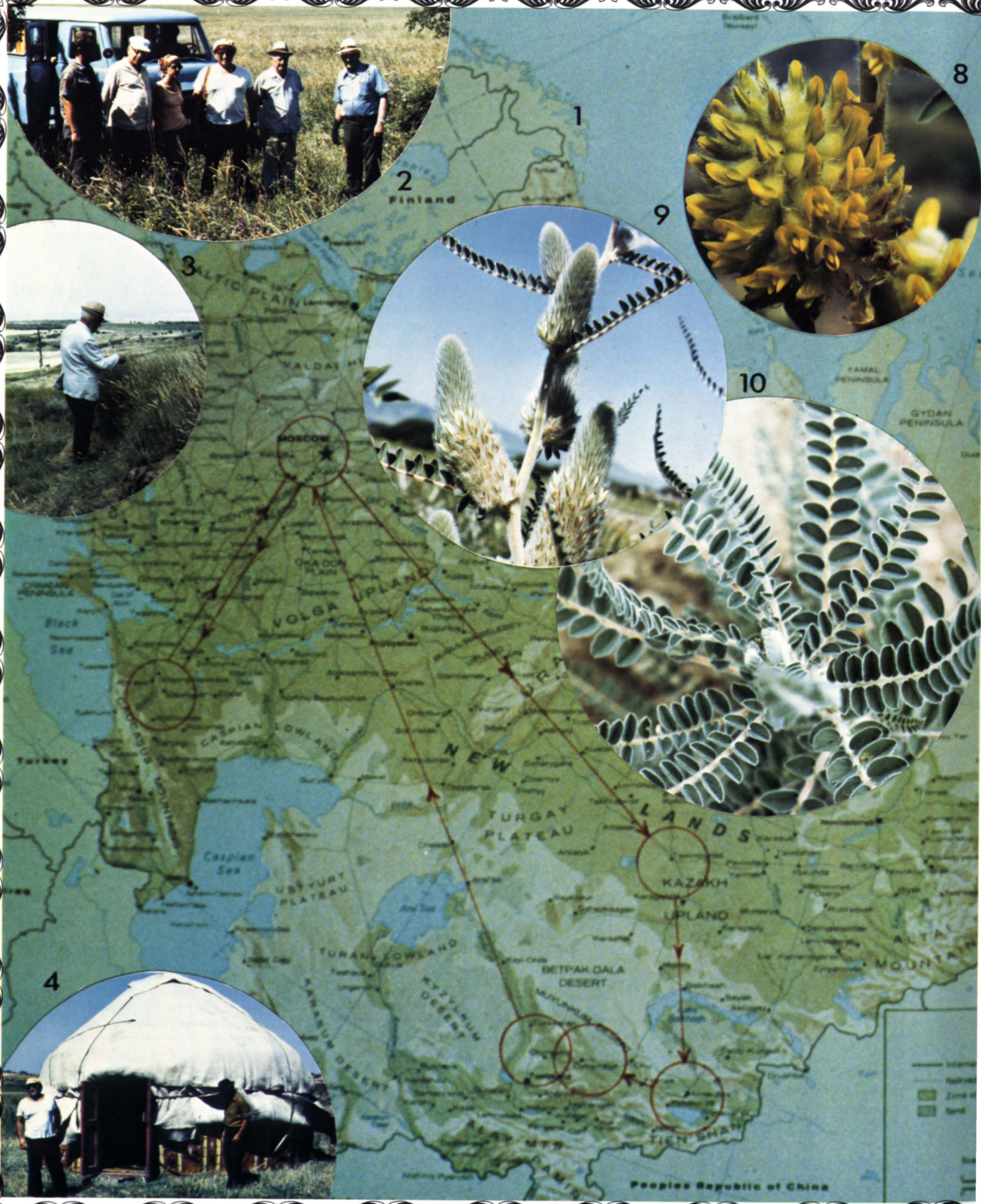
For 30 years, Dr. Cronin has worked on characteristics and conditions that allow poisonous plants to thrive on our rangelands. His work in controlling poisonous plants and improving forage production includes three bulletins: on halogeton, the poisonous milkvetches, and the larkspurs. Dr. Cronin is now researching the locoweeds.

Darwin B. Nielsen is Professor of Agricultural Economics. His research interests are in range and ranch economics of beef cattle and sheep production, emphasizing management decision making. In addition, Dr. Nielsen is interested in the economic impacts of federal government regulations and policies on the range livestock industry.

EDITOR'S NOTE

Drs. Cronin and Nielsen have collaborated to produce the ecological research and economic analysis, respectively, of "The Ecology and Control of Rangeland Larkspurs," UAES Bulletin 499. This bulletin may be obtained by writing the Bulletin Room, UMC 48, USU, Logan, UT 84322, or by telephoning (801) 750-2251.

*These figures are based on 1978 data. Today, animal values have risen proportionately higher than have the control costs which gives an even higher rate of return to the rancher.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VOLGA UPLAND
Black Sea
Turkey
CASPIAN LOWLAND
NEW LANDS
TURGAY PLATEAU
Caspian Sea
USTYURT PLATEAU
KAZAKH UPLAND
TURAN LOWLAND
KYZYLKUM DESERT
BETPAK DALA DESERT
TIEN SHAN
YAMAL PENINSULA
GYDAN PENINSULA
Peoples Republic of China

An Asian Treasure Hunt

WITH PLANTS IN MIND

DOUGLAS R. DEWEY

PLANT SPECIES THAT ARE THRIVING under certain conditions (climate, soil, elevation) in one part of the world often do as well or even better in other locations that have comparable conditions. Or, the interbreeding of related species from different regions can sometimes produce outstanding hybrids

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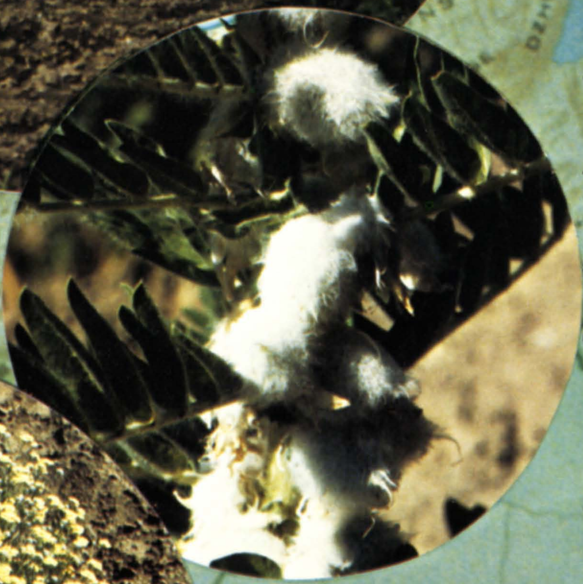

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1. Map of U.S.S.R. showing route and major collecting areas of the Dewey-Plummer expedition in 1977.

2. Soviet plant collectors and Mr. A. P. Plummer (far right) at a rich collecting site near Stavropol.

3. Soviet botanist assisting in the collection of crested wheatgrass near Stavropol.

4. A Kazakh tent 50 km into the Moyun Kum Desert on almost inaccessible roads.

5. An ornamental *Achillea* (yarrow) species.

6. An *Astragalus* collection with large woolly pods.

7. Soviet plants established on the Evans Farm of the Utah Agricultural Experiment Station near Logan, Utah.

8. The large *Astragalus* species used by the Soviets for silage also have attractive flowers.

9. A perennial *Astragalus* species has potential as a forage and an ornamental.

10. Intricate velvety leaves envelope unusual cylindrical seed heads.

Plant geneticists working on specific problems (such as revegetating arid or semi-arid rangelands) thus are always eager to obtain seed from outside their own country.

Asian/Russian grasses, legumes, and shrubs have already substantially aided attempts to enhance range forage productivity in the western U.S. But the general consensus is that the potentials have been barely skimmed.

As a "have-not" nation relative to native, agriculturally important plant species, the U.S. has traditionally drawn from around the world for crops such as alfalfa, tomatoes, rice, soybeans, and small grains. When attention turned to revegetating abused western ranges, plant introductions of wheatgrasses, wildrye grass, smooth bromegrass, and orchard grass were considered crucial. Initial efforts, however, tended to involve relatively few plants of each type. The limitations imposed by such a constricted gene pool, which restricts vegetative capacities to adjust to stresses, made expanded seed collections imperative.

The possibility of collecting forage-plant seeds in Russia therefore intrigued me long before the mid 1960s, when I first began to seriously prepare for such an expedition. With my primary plant breeding interest being in grasses and other forages for western rangelands, the chance of collecting seeds within Russia seemed worth the long years of preliminary groundwork and the maze of red tape.

In 1977, A. P. Plummer (a range scientist with the USDA Forest Service) and I happily took advantage of an authorization for a 45-day collection trip to five locations in Russia. Since "mail-order" exchanges had proved essentially unsatisfactory, we were enthusiastic about being able to see, evaluate, and collect from wild-growing plants that might speed our plant breeding progress in the U.S.

The Harvest

During the allotted 45 days, seeds were taken from about 1,100 range-forage grasses, legumes, forbs, and shrubs. Some came from Botanical Gardens, but most specimens were collected in the wild with the aid of Soviet botanists.

Almost three weeks (July 20 to August 6) were spent in the Stavropol Kray in the northern foothills of the Caucasus Mountains. This area is moderately humid with 400 to 1,000 mm (15 to 40 inches) precipitation and has a rich mixture of grasses and legumes. More than 600 collections were made. An unusually large collection of *Trifolium ambiguum* was obtained from the Stavropol Botanical Garden. Significant collections were made in the wild of: *Agropyron, Bromus, Festuca, Phleum, Lotus, Medicago, Trifolium, Vicia,* and *Onobrychis.*

Five days (August 7 to 11) were spent collecting in the New Lands area near Tselinograd in northern Kazakstan, with the Shorthandy Grain Research Institute as the base of operations. This area is flat prairie land with severe winters and less than 300 mm (12 inches) precipitation. About 125 collections were made of *Agropyron, Elymus, Bromus, Medicago,* and miscellaneous species.

Five days (August 12 to 16) were spent in the vicinity of Alma Ata, the capital of Kazakstan. The most productive collecting was done in the low mountains (Tien Shan range) where about 100 collections were obtained of miscellaneous grasses, forbs, and shrubs.

Another five days (August 17 to 21) were spent in the desert regions around Dzhambul in southern Kazakstan. This area receives only 100 to 300 mm (4 to 12 inches) precipitation each year. About 100 collections were made on these true desert sites. The most significant collections were of crested wheatgrass (*Agropyron sibiricum*) and *Astragalus* species, which grew in sand dunes. Dzhambul was the only area where we located *Elymus multicaulis,* the Asian counterpart of North American *Elymus triticoides.*

The final week (August 22 to 28) was spent around Chimkent about 100 km west of Dzhambul. Almost 150 collections were made in this area. Good collections were made of *Agropyron, Elymus, Bromus,* and *Dactylis.*

Seeds of desert shrubs were immature in all areas, so collections were few during the trip.

The willingness of our scientist hosts at each location to provide well beyond minimal assistance was instrumental in the successes we catalogued. The disappointments (e.g., inflexible itinerary, cumbersome seed quarantine procedures, and time wasted at unproductive sites) allowed us to satisfy only approximately 50 percent of our original goals. That 50 percent, however, promises to facilitate an invaluable upgrading and extension of U.S. range productivity.

What's Ahead

In the late fall of 1977, after the seed had been released by quarantine officials, the entire collection was shipped to Logan, Utah, for threshing and cleaning. After threshing, about half of each seed lot was retained at Logan and the remainder was sent to the Regional Plant Introduction Station at Pullman, Washington. Some of the species will be grown and increased at Pullman and others will be increased at other Plant Introduction Stations. In the meantime, plant introduction (PI) numbers were assigned to each collection and they became officially incorporated into the National Plant Germplasm System.

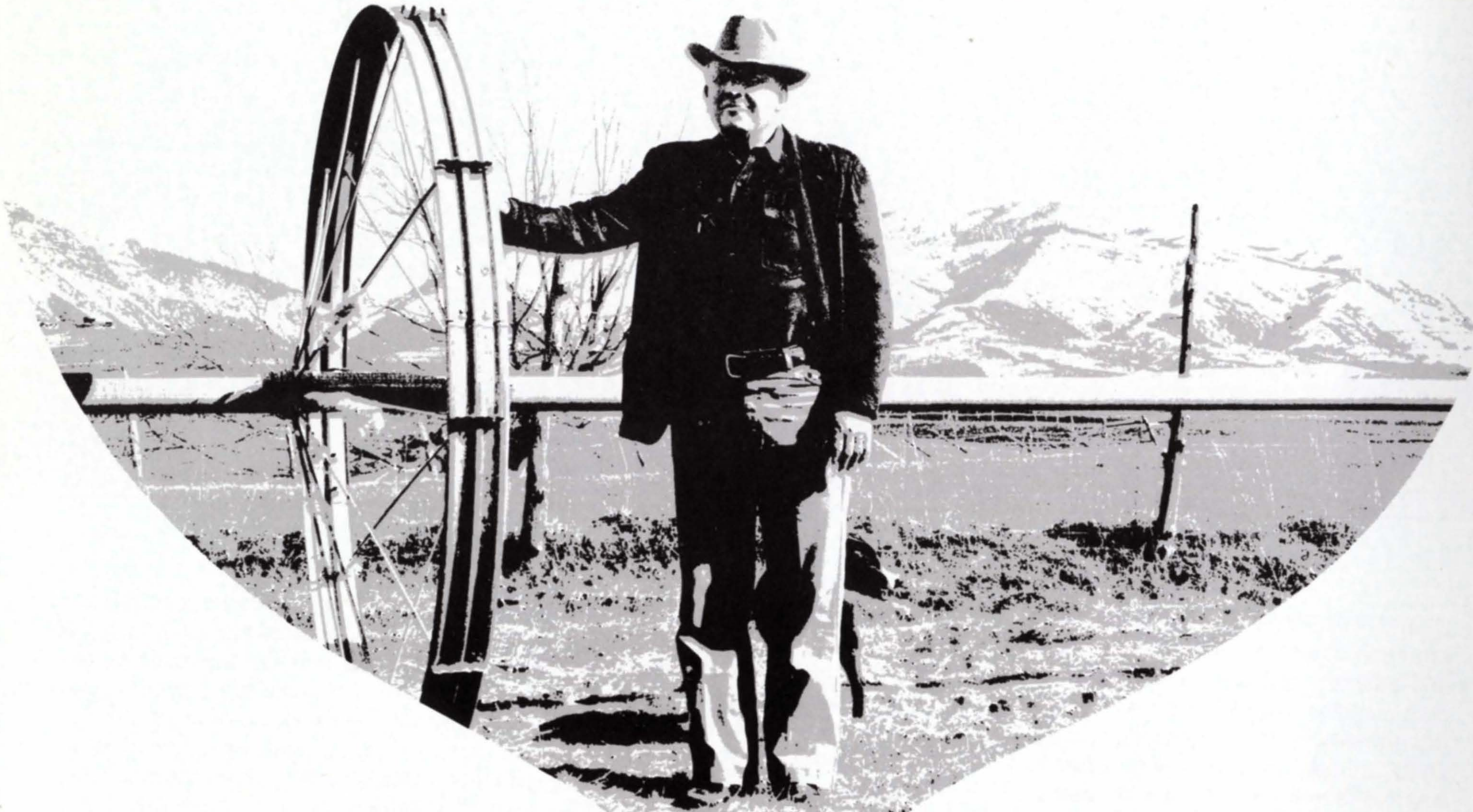
The only location where the entire collection is being grown is Logan. All of the seed lots that could be germinated readily, about 90 percent of the total, were planted in the spring of 1978 in a 2-hectare planting on the Evans Farm of the Utah Agricultural Experiment Station. Ordinarily, 10 plants were established from each collection.

Some of the collections have ornamental as well as forage value, and will be evaluated for general adaptation at Logan. Great care is being exercised to prevent the escape or release of any plants that might become weeds. With the aid of USU's Dr. M. C. Williams (USDA-SEA-AR), plants that contain toxic compounds will be identified.

Seed of collections that appear to be useful for range and pasture purposes will be increased at Logan. Other collections will be increased at the various Plant Introduction Stations. As seed is increased in 1979 and later years, it will be made available to individuals and institutions for further research and evaluation. Anyone interested in this collection is encouraged to observe the planting at Logan.

ABOUT THE AUTHOR

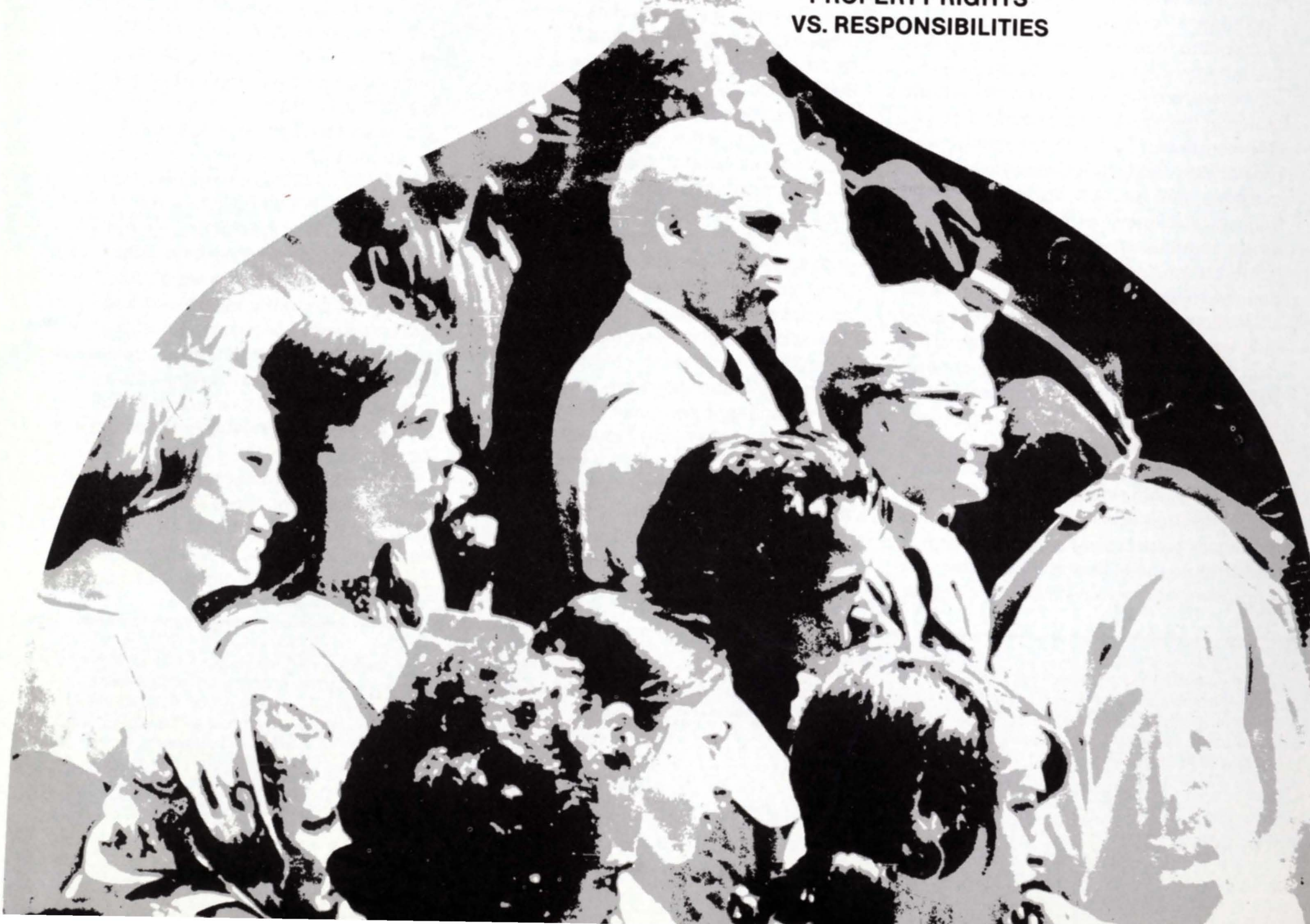
The past 20 years, Douglas Dewey's research has been largely devoted to the study of the cytogenetic, phylogenetic, and taxonomic relationships among the perennial grasses of the Triticeae tribe. An extensive collection of species, species-hybrids, and induced-amphiploids have been assembled and synthesized during this time. Dewey studied at the Royal Botanical Gardens in Kew, England, and at Komarov Botanical Institute, Leningrad, USSR before leading collecting expeditions to Iran in 1972 and Russia in 1977. He is a Research Geneticist (USDA-SEA-AR) and Professor of Plant Science at USU.



PRIME FARMLAND

A CRUCIAL DEBATE

PROPERTY RIGHTS VS. RESPONSIBILITIES



W. CRIS LEWIS

LAND USE CONTROLS AND AGRICULTURAL PRODUCTION

URBAN GROWTH, highway construction, changes in commodity prices, and a variety of other factors, are continuously pushing land from one use to another. To some, these resource shifts are seen as a problem, especially when land moves out of agricultural production. Newspapers consistently report the opposition of one group or another to a proposed land-use change on the grounds that farmland will be taken out of productive use. The arguments often revolve around "shortages" of food and "high" food prices, and to some, these dictate that the land be kept in agricultural use.[a]

There are many who favor some form of social (i.e. government) control of land-use resources such as zoning ordinances, land-use planning commissions, and the like. Apparently, the majority of Utahns, at least those in the urban counties, are desirous of controls[b] but prefer local (i.e. city and county) to state or federal control.[c]

Economists argue that efficient use of land as well as all other resources will occur when private markets are allowed to allocate resources unrestrained by government regulation. They argue that land-use control by government is likely to be not only inefficient but also inequitable. As a result, the application of the controls will be a source of continual controversy as government redistributes wealth and income by approving or denying land-use changes.

II

SOCIAL CONTROLS requiring land be kept in agricultural use are not necessary to maintain or increase the level of agricultural production. The evidence can be briefly summarized; American agriculture has generated very large production increases over the past 40 years with no significant increase in the quantity of land used. There is no apparent reason to expect this will not continue.

Assume that a parcel of agricultural land used to produce corn is in demand for residential use at a value several times that in agriculture, and that the land is converted to housing use. Because both the demand and supply functions for corn are relatively inelastic,[d] the initial effect is that the price of corn rises proportionately more than the quantity produced decreases. The short-term result on agriculture generally is greater revenues to farmers and, therefore, greater net receipts; the latter should rise proportionately more than revenues because of the cost saving from not farming the parcel in question.

Generally, the long-term response of any rational entrepreneur to higher prices and profits is to increase production. Thus, it is likely that other land will be farmed more intensely and that new land will be brought into production. Total production actually may increase. Indeed, the data outlined below are consistent with this hypothesis. Total land in agricultural use has remained roughly constant since 1940. During this period land absorbed by growing urban areas has been replaced with other land, and production has increased dramatically. To the extent that this model is accurate, the free movement of land out of agriculture, in fact, is totally consistent with increasing food production.

While the technical explanation is beyond the scope of this paper, the net result of a land-use control requiring that land stay in agricultural use may be reduced output in the long run. The argument is the converse of that just outlined. Prices, revenues, and profits would not increase in the short run, thus providing no incentive to expand production.

Finally, a USDA survey identified approximately 630 million acres of land as suitable for regular cultivation. Of this amount, only 58 percent (365 million acres) are in regular cropland use. The remainder primarily is in forest and grass. Clearly, the potential for expansion of cropland is there. The reason that more land is not in agricultural production is simply one of economics, not because of limitations on availability of land.

Of the 2.3 billion acres of land in the United States, no more than 50 million (about 2 percent of the total) are used for urban activities. To put this in perspective, as recently as 1972, an

[a] In many cases, the opposition to the land-use change actually is based entirely on other considerations, but the agricultural production issue is seen as being a more acceptable argument.

[b] This conclusion is based on the widespread use of zoning in those areas and the defeat of the state land-use planning referendum in 1975.

[c] Of course, the federal government exercises almost absolute control over about two-thirds of the land area of the state. The growing pressure in the West to assume state control over what is now federal suggests some dissatisfaction with federal management of these lands.

As our communities grow, land sales increase. Here, Cache Valley pasture land is offered. Mike Jackson

amount of cropland larger than that in all urban areas of the country was diverted from crop production as a result of federal set-aside and related programs designed to reduce the downward pressure on commodity prices. These set-asides were largely eliminated in 1974, but recent pressure on commodity prices in 1978 and 1979 has resulted in cropland again being taken out of production under government subsidy programs.

The point is that it is somewhat inconsistent to be arguing for land-use controls to preserve farmland on relatively few acres when the federal government has been paying farmers not to produce on millions of acres and when millions of acres of potential cropland are not being cultivated.

III

LAND IS ONLY ONE of several inputs in the agricultural production process. It can be substituted for other inputs and the latter can be substituted for land. That is, agricultural production can occur with an infinite variety of input combinations, the best being determined by the relative prices of the inputs and the production technology.

This concept can be demonstrated by reference to a production function which relates a level of output (Q) to levels of inputs of productive factors. In agriculture, these inputs could be grouped into labor (E); machinery, buildings, and other capital equipment (K); fertilizer and other agricultural chemicals (F); water (W); and land (L). In addition, the level of technology (T) must be included as each year the agricultural industry generates more output from given input levels. Thus, the production equation could be written:

$$Q = f(E,K,F,W,L,T).$$

Now, agriculture is no different than most industries; it is possible to increase production by increasing any one input.[e] In fact, one or more inputs can be declining over a long period of time and output can still increase as other inputs are substituted for one that is declining.

How do we know which inputs should be increased and which should be decreased? Fortunately for those of us who are simply consumers of agricultural products, we need not worry about this. The individual farmer responding to changing demands in the marketplace for his products and to changing prices of the several inputs will take care of these problems for us. In fact, this is one of the great advantages of the free enterprise system; we rely on a large number of relatively small entrepreneurs to make those decisions that turn out not only to be in their best interest but also in the best interest of all consumers. As the farmer strives to maximize his net cash receipts, we can expect him to efficiently combine various amounts of each of the relevant inputs in production of those products that are in the greatest demand. This point was made by Adam Smith in the first great economics textbook, *The Wealth of Nations,* first published in 1776,[f] and continues to be an integral part of economic theory.

IV

WHAT HAS BEEN the actual experience in American agriculture? As a matter of fact, excluding technology, the total input of resources of agricultural production has increased very little since 1940. As shown in Table 1, which reports index numbers of various farm inputs, the measure of total input has increased only 12 percent in 37 years. During this period, output was increasing rapidly. Of course, the total input index masks some rather substantial substitutions of one input or another. For example, as is well known, there has been a massive decrease of labor in farm employment. Total farm employment has declined from 11 million workers in 1940 to approximately 4.2 million in 1977; only 38 percent of the 1940 employment level is still in agriculture. Over this period, there were significant increases in the application of mechanical power and agricultural chemicals in farm operations. Farmers have rapidly adopted and, in many

[d] An inelastic supply or demand function is characterized by a proportionately larger change in price when the quantity supplied or demanded changes.

[e] While this discussion is in the context of the agricultural sector in total, in many cases the principle of substitution applies equally to the individual farm.

[f] Currently available from the Modern Library, New York.

cases, were instrumental in developing new production techniques, seed varieties, and improved agricultural chemicals; indeed, the highly competitive economic environment dictates that farmers must incorporate new developments almost immediately in order to maintain profitability.

It is significant that despite the expansion of urban areas and other activities that have bid land away from agriculture, *the total amount of land in farms and in crops is essentially the same today as it was in 1940.* In fact, after declining steadily from 1950 to 1970, the amount of cropland has increased 17 percent since 1970, and this has been the period that the loudest protests have been made about use changes for agricultural land!

Remarkably, despite the relatively small increase of total inputs in agriculture, the change in agricultural production in the United States is nothing short of staggering. For example, over the last 35 years, wheat production increased 150 percent, corn production was up 188 percent, soybean production had increased 20-fold. Similar increases have been recorded in beef and pork production (see Table 2). With a constant level of other inputs, the explanation for this output increase lies in the continuous application of new production techniques, new seeds, and more and better fertilizers and equipment; these have been substituted for land and labor.

The increase in the productivity of agricultural employment has been more rapid than any other broadly defined sector. In 1940, each farm worker produced enough food for 12 Americans. By 1977, each farm worker was producing enough food for 53 people in the United States and others in foreign countries. Exports of agricultural products from the United States have increased dramatically in recent years. Not only is the American farmer producing for America but for the rest of the world as well.

Between 1950 and 1977, farm output per man-hour increased at an average annual rate of 6.1 percent. This compares to annual rates of 2.2 percent in the private business sector, and 2.6 percent in manufacturing. Clearly by this measure, agriculture stands out as one of the most productive, if not the most productive, sector in the domestic economy.

What has been the experience in Utah? It is not surprising that it closely parallels that for the nation. As shown in Table 3, production of the most important agricultural products has been far more rapid than the increase in land inputs. In fact, since 1960, land in farms has declined more than 5 percent, with output of hay, cattle and calves, and milk up 47, 127, and 22 percent, respectively.

V

IT HAS BEEN DOCUMENTED that the American agricultural sector has been among the most productive of any broad industrial segment of domestic economy. Although there is significant government involvement in the agricultural arena, the industry is characterized by a large number of relatively small producers, each of whom puts his labor, capital equipment, and land resources to what he sees as their highest and best use. One result of these many millions of decisions made over a number of years has been to contribute significantly toward the achievement of the highest living standard of the world.

Clearly, land is only one of several inputs to the agricultural production, and its level of use has been approximately constant for 40 years. This notwithstanding, massive increase in output has been achieved. Increased application of agricultural chemicals, water, mechanical equipment, and a large dose of technological advance have substituted for land and labor.

Given this history, it seems illogical to argue a need for government control of agricultural land resources. If the last 40 years are any indication, the individual farm operator knows best the use of that land. If the highest and best use is some nonagricultural activity, such as residential housing, then so be it. Frankly, this writer is looking to the individual farmer for leadership on the allocation of land between agricultural and nonagricultural use. He has been doing the job in an exemplary fashion for many decades; there is no reason to expect this not to continue.

Who best qualifies to determine what that most efficient input combination is in agriculture? This paper takes the position that it is the individual farmer; certainly, it is not some local land-use planning board. The farmer knows the prices of farm products and inputs, he knows the production technology, the climatic conditions, and the marketing techniques. Most important, he personally bears the cost of being wrong; clearly, no business operator can be wrong very often without going out of business. Government regulations bear little or any of the cost of being wrong. They can make the same errors year after year; indeed, the problems caused by being wrong are often used as the basis for more regulations.

One final problem of land-use controls has not been discussed. Land-use restrictions impose equity problems on a subset of the population. Requiring land to be kept in agriculture, when it is worth more in some alternative use, implies an opportunity cost for the landowner. Consider the case of a farmer who has, say, 100 acres on the fringe of a growing urban area. Assume realistically that the per-acre value is $1,000 in agricultural use and $15,000 if the land were converted for residential housing and/or commercial use. To require that land to stay in agricultural use means the owner foregoes a wealth increase of $1.5 million. In addition, prices of residential and/or commercial properties would be higher than they would be otherwise because their supply is held down. Thus, purchasers of homes and/or shoppers are faced with a narrower range of choice and higher prices as a result of such a land-use control decision. Thus, those who favor the land-use control presumably enjoy some sort of psychological or aesthetic benefit or other benefit from having that land maintained in agricultural use, but the individual landowner incurs a sizable economic loss. In addition, a number of other unidentified persons (e.g., purchasers of homes) bear additional costs. These factors are rarely taken into consideration when land-use decisions are made, but they are not unimportant.

It can be shown in a competitive environment that the strategy of maximizing aggregate land values will result in maximum economic welfare for society. In general, there is no need for any type of government intervention in the land allocation process to achieve this goal; the operation of free market forces will result in land going to its highest and best (i.e. highest value) employment. That some prefer the open space and other aesthetic characteristics of farmland to the characteristics of an alternative use is irrelevant. If they feel strongly enough about their preferences, that group should muster their resources and purchase the property. They could maintain its current agricultural use, and that would be socially efficient. To require that someone else bear the cost of maintaining it in that use is neither efficient nor equitable.

Finally, how much farmland is enough? Those who oppose shifts of land from agricultural to other uses implicitly assert they know how much. Unfortunately, they are never asked to document that claim. How much is enough in Utah? The author would say currently it is about 12.9 million acres. In 1960, it was 13.6 million acres. How much will be enough in 1980? Ask me in 1981, when the data on land use are reported; we can count on farmers to use just the right amount.

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Residential development is not limited to large urban areas; here, Providence, Utah, homes spread into farmlands.

Mike Jackson

Table 1. Index Numbers of Farm Input by Major Subgroups, United States, 1940-1977 (1967 = 100)

Year	Total Input	Farm Labor	Mechanical Power and Machinery	Agricultural Chemicals[a]	Farm Real Estate	Land: Farm-Land	Land: Crop-land
1940	91	282	39	13	92	98	111
1950	94	208	80	31	97	107	113
1960	94	148	93	46	100	104	106
1970	99	90	100	115	98	97	96
1977	102	78	114	146	94	99	112
Percent Change							
1940-77	12.1	− 72.3	192.3	1,023.1	2.2	1.0	0.9
1960-77	8.5	− 47.3	22.6	217.4	− 6.0	− 4.8	5.7

SOURCE: U.S. Department of Agriculture (1967, 1978).

Table 2. Index Numbers of Farm and Related Output by Major Commodities, United States, 1940-1977

Year	All Wheat	Corn for Grain	Soybeans	All Hay	Beef	Pork
1940	54.0	45.4	8.0	76.8		
1950	67.6	56.9	30.6	83.0	47.2	85.2
1960	89.9	80.4	56.8	94.4	73.0	92.3
1970	89.7	85.4	115.4	101.5	107.3	106.8
1977	134.4	130.8	175.8	104.7	125.2	105.4
Percent Change						
1940-77	148.9	188.1	2,097.5	36.3		
1960-77	49.5	62.7	209.5	10.9	71.5	14.2

SOURCE: U.S. Department of Agriculture (1967, 1978).

Table 3. Selected Agricultural Statistics, Utah, 1940-1978

Year	Land in Farms (1,000 Ac)	All Wheat (1,000 Bu)	All Hay (1,000 Tons)	Cattle and Calves (1,000 Lbs)	Milk (Million Lbs)
1940	10,100	5,466	1,059	105,545	550
1950	12,000	7,840	1,020	157,125	655
1960	13,600	5,292	1,281	217,665	764
1970	13,200	6,081	1,638	256,121	819
1978	12,900	5,599	1,886	276,710	935
Percent Change					
1940-78	27.7	2.4	78.1	162.2	70.0
1960-78	− 5.4	5.8	47.2	127.1	22.4

SOURCE: Utah State Department of Agriculture, 1979.

ALVIN R. SOUTHARD

EXPENDABLE ACRES? A SCENARIO FOR THOUGHT

EVERY DAY IN THE U.S. FOUR SQUARE MILES OF PRIME FARMLAND ARE SHIFTED TO USES OTHER THAN AGRICULTURE. This amounts to about one million acres per year. Another two million acres of lesser quality land are lost to non-agricultural uses annually. These figures, reported in a pamphlet recently published by the National Agricultural Lands Study Group composed of eleven agencies, may not sound impressive relative to the total U.S. land base. But the key word is "quality."

Contrary to some utopian thinking, *poor* quality land cannot be routinely converted into prime farmland. Such conversion is already prohibitively expensive and may become impossible in the near future because of the exorbitant energy inputs that are required at all stages. These costs could be aggravated by our dependence on imported oil and pricing policies for domestic fossil energy sources.

But the quantity of land, too, is important. A loss of only one-half as many acres annually to non-agricultural use will eventually devastate the nation's agricultural base. If this trend continues unaltered, in ten years we'll have lost the equivalent of the thirty million acres of rural non-federal cropland in Texas (Table 1*). In twenty or fewer years, we may thus be more disturbed about food shortages than we are today over the shortage of petroleum.

In 1978, the U.S. had a $27 billion income from agricultural exports. The implications of our being unable to maintain this export status because of insufficient prime farming lands are impressively bleak. Our industrial and military strengths are founded on a productive agriculture. Yet, on a national basis, little is being done to guarantee that enough prime farmland will remain in agricultural production to insure adequate food for future generations. In 1979, agricultural production of industrialized nations as a whole was reported to be down by about 3 percent. Only the United States produced more in 1979 than in 1978—scarcely cause for complacent erosion of our agricultural base.

WHAT HAS BEEN HAPPENING

Historically, the ownership of land in this country has carried with it the right to do as one pleases with that land without regard for the welfare of society. This egocentric tradition has been interpreted by some as meaning that the marketplace is competent to decide which tracts of land are used for what purpose. The inherent selfishness in such an approach may no longer be tolerable. With it, individuals who are financially able to buy, sell, or hold land can have inordinate influence on land use patterns.

For example, prime farmland acreages in California and Hawaii that were in agricultural production in 1950 have been overrun by seekers of equable climates for living. These areas offered a unique flexibility in the range of crops that could be cultivated. Such potentials cannot be "created" by human ingenuity. The aerial photograph of Valencia, California, dramatically illustrates the impact of housing developments on lands previously devoted to agricultural uses requiring a special combination of soil, climate, and water. The rush of population to semi-comparable parts of the Southwest and the Southeast is unlikely to slow. Only sound regional and national land use policies can reserve land for the food, feed, and fiber production that is essential to our health and economic stability now and in the future.

It can be no surprise that the land preferred by developers is often prime agricultural land. Salt Lake County exemplifies the usual results: most of the county's prime farmland of 1950 is now supporting subdivisions. Similarly, a study in Illinois (Higgens 1955) found that two-thirds of the cropland converted to urban uses fell into farmland capability classes I and II (high production with minimal inputs). Today's marketplace favors a reckless pursuit of profits. Tomorrow's food supply may judge that attitude, a madness.

Arguments that land use decisions may be safely decided by market forces have strong appeal, especially for those hoping to reap substantial profits from land ownership manipulations. This is understandable since many individuals use investment in land as a hedge against inflation and as a personal retirement program. Certainly these goals must somehow be satisfied. But, can a process that imposes such foreseeably substantial costs on future generations be condoned by the public?

Informed planning by concerned citizens seems a more desirable approach. Prime acres can be kept in agricultural production without violating private property rights. Among some possible solutions are purchase of development rights, special tax incentives extended to farmers as long as the land is kept in agricultural production. Whatever the solution, it must be directed toward protection of private property rights and must enable the farmer to remain in a competitive economic position. But achieving those goals takes planning of a sort which

*From 1980 Review Draft, Program Report and Environmental Impact Statement, USDA/SCS, Soil and Water Resource Conservation Act.

Housing development moving in on prime California farmlands. Alvin Southard

U.S. citizens have never had to practice. The marketplace, which is acknowledged to be less than perfect, even by its most dedicated adherents, is not an adequate mechanism when left to its own devices.

MARKETPLACE SHORTCOMINGS

For the most part, marketplace decisions relative to land use are irreversible. Once an error is made, it is virtually impossible to correct it. For example, land used for interstate highways cannot be readily returned to agricultural production because every engineering procedure for building the highways creates an inhospitable environment for plant growth. Restoration of the topsoil to anything near its original condition is almost impossible physically and is certainly economically impractical.

The market does not take into account the health, welfare, and safety of society. Market forces, therefore, are most unlikely to provide space for parks, schools, and recreation activities. Planning that takes into account human needs beyond money must intervene.

Market-induced leapfrog or buckshot urbanization generally has an adverse impact on adjacent farmland. Many dairy farmers in Utah, for example, are being forced to quit or to move to less profitable locations because of encroaching subdivisions.

The enormous yields and surpluses of most agricultural products that we in the United States take for granted make it difficult for most people to believe that alarm is justified. In this situation, however, if we wait for the crisis before taking corrective action, the irreversibility factor may be insurmountable by even the most ingenious scientific technology.

THE COST/BENEFIT RATIONALE

Concern over the shrinking quantities of prime agricultural land can be advantageously discussed in terms of long-run considerations of market efficiency and equity. Land use policy, to be viable, must address the issue of insuring adequate supplies of land to competing uses, both now and in the future. This can be accomplished if the market acts in conjunction with attempts by local, state, and federal governments to guide land allocations toward policy objectives.

Left to market forces, the ultimate use of land now in agricultural production will be determined by the current relative profitability of the competing uses. From the point of view of the current land-owning generation, this has great appeal since they thus maximize the land's net benefits for themselves. Future generations, however, may thereby inherit an excessive housing stock relative to their valuation of agricultural goods and services. By irreversibly allocating land to non-agricultural uses in the current period, the present generation imposes excessive costs on future generations, whose members will be unable to maximize their net benefits from the use of the land and simultaneously lack a land base for food production.

If the present generation maximizes its own welfare—its profits on a short-term basis—future generations may bear unprecedented social costs in the form of foregone net benefits on a long-term consideration. On the other hand, curbing urban development to insure flexibility for future land use decisions imposes excessive costs on some members of the current generation. Neither of these extreme outcomes is efficient. The current generation should refrain from development only up to the point at which the discounted net marginal benefit to future generations equals the net marginal benefit being foregone in the present generation.

There is a strong logical presumption, based on past experience, to expect that market allocations of land will tend

Table 1. Western rural (nonfederal) cropland in 1977

State	Cropland Irr.	Cropland Nonirr.	Pasture, native pasture & rangeland	Forest land	Other	Total
			(1,000 acres)			
California	8,355	1,738	18,688	9,857	11,077	49,715
Colorado	3,487	7,601	25,403	3,343	2,194	42,028
Kansas	3,331	25,477	18,975	786	2,444	51,013
Montana	2,262	13,096	41,484	6,343	2,415	65,600
Nebraska	6,908	13,758	24,896	439	1,803	47,804
North Dakota	77	26,857	12,113	368	2,938	42,353
Texas	8,284	22,146	114,174	9,240	6,050	159,894
Utah	1,250	565	9,989	1,066	3,158	16,028

[1]USDA. 1978. Forest Statistics of the U.S., 1977.
NA = Data not available.
Source: 1977 National Resource Inventories


INVESTERS Developers, 38 acres, choice farm land, over looking popular Willard Bay State Park, north marina, within Willard city limits. Good development, or investment property, culinary water, gas and other services avail. 5 minutes from park and freeway, presently planted to orchard, row crops and pasture, with or without home. No commission to pay! Owner will carry contract.

Newspaper ads like this one are seen regularly throughout the country.

to result in an excessive conversion of cropland to other uses. A long-run efficient allocation would require that people at all levels of government and within the general public cooperate to establish land resource allocation objectives based on scientifically reliable, extensive resource data.

IMPLICATIONS FOR LAND USE POLICY

To develop successful local farmland preservation programs, two issues must be carefully analyzed. First, to justify program costs, there must be evidence that regional land markets are overallocating land to urban development at the expense of prime cropland to a substantial degree. Preservation programs *do* have inherent costs and are not totally efficient in terms of achieving equity between present and future generations. Government agencies (at *all* levels) of necessity work with imperfect information about future benefit and cost relationships in land markets. Also, the true potentials of certain parcels of lands to support perceived possible uses may not be known because data are lacking. For example, decisions to put housing developments on land in excess of the land's capability to absorb the impact lead to many costs which society is asked to bear. If the market and institutions had been informed about the land capability then allocation could have been different.

If it appears that in a particular case or area, government intervention to help preserve regional cropland is preferable to unguided market allocations, the second crucial policy question is what specific type of preservation programs should be implemented. Among the approaches already in operation are: restrictive agreements (California), agricultural districts (New York), statewide zoning (Hawaii), purchase of development rights (Connecticut), and use-value assessment (Arizona and Utah). Each of these approaches to cropland preservation impose varying program costs on affected parties. To be efficacious—both viable and productive—a program must attempt to keep costs low while equitable, distributing program benefits and costs between present and future generations.

IS IT WORTH THE BOTHER?

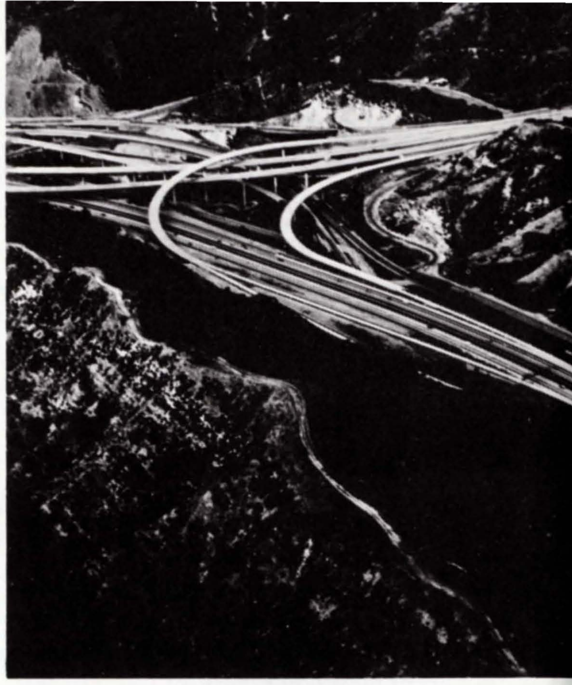
Careful research on these land-use policy issues can result in substantial benefits to the communities directly involved as well as the nation as a whole. At the local level, the active engagement and cooperation of landowners and other concerned citizens must precede any successful land resource allocation program. Reasonable land use allocation policies can be reached locally by:

1) Objective, accurate research in local land use trends, and
2) extensive participation by local landowners and other concerned citizens acting from a sound data base with land market constraints.

Unless a rational land use solution is obtained by local action eventually:

1) Land for agricultural production will be in short supply,
2) food shortages will occur,
3) agricultural production will become a national issue,
4) federal government will intervene in private property rights issues, and
5) specific areas of land will be assigned to grow specific crops.

In short: If we don't do it ourselves, government will.



Massive highway interchanges lace hillsides in California much as they are tying up farmlands in the rest of the country.

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EDITOR'S NOTE:

The Utah Agricultural Experiment Station is publishing a series of research reports by Dr. Southard showing the important farmlands of Utah counties (each of which includes a large, detailed map in color). The reports for Cache, Salt Lake, and Box Elder counties can be obtained from the Bulletin Room, UMC 48, Utah State University, Logan, Utah 84322, or by telephoning (801) 750-2251. The rest of these reports will be published in the near future.

ABOUT THE AUTHOR

Alvin R. Southard is a Professor in the Department of Soil Science and Biometeorology, Utah State University. He is also State Soil Survey Leader for the Utah Agricultural Experiment Station, Chairman of the Technical Land Use Committee of the Soil Conservation Society of America (Utah Chapter), and past Chairman of the Western Regional Research Committee for Land Use Planning.

The author wishes to acknowledge the contributions toward this article by Dr. Dennis Cory, Assistant Professor of Agricultural Economics, University of Arizona.

Will it become necessary one day to reverse the process?

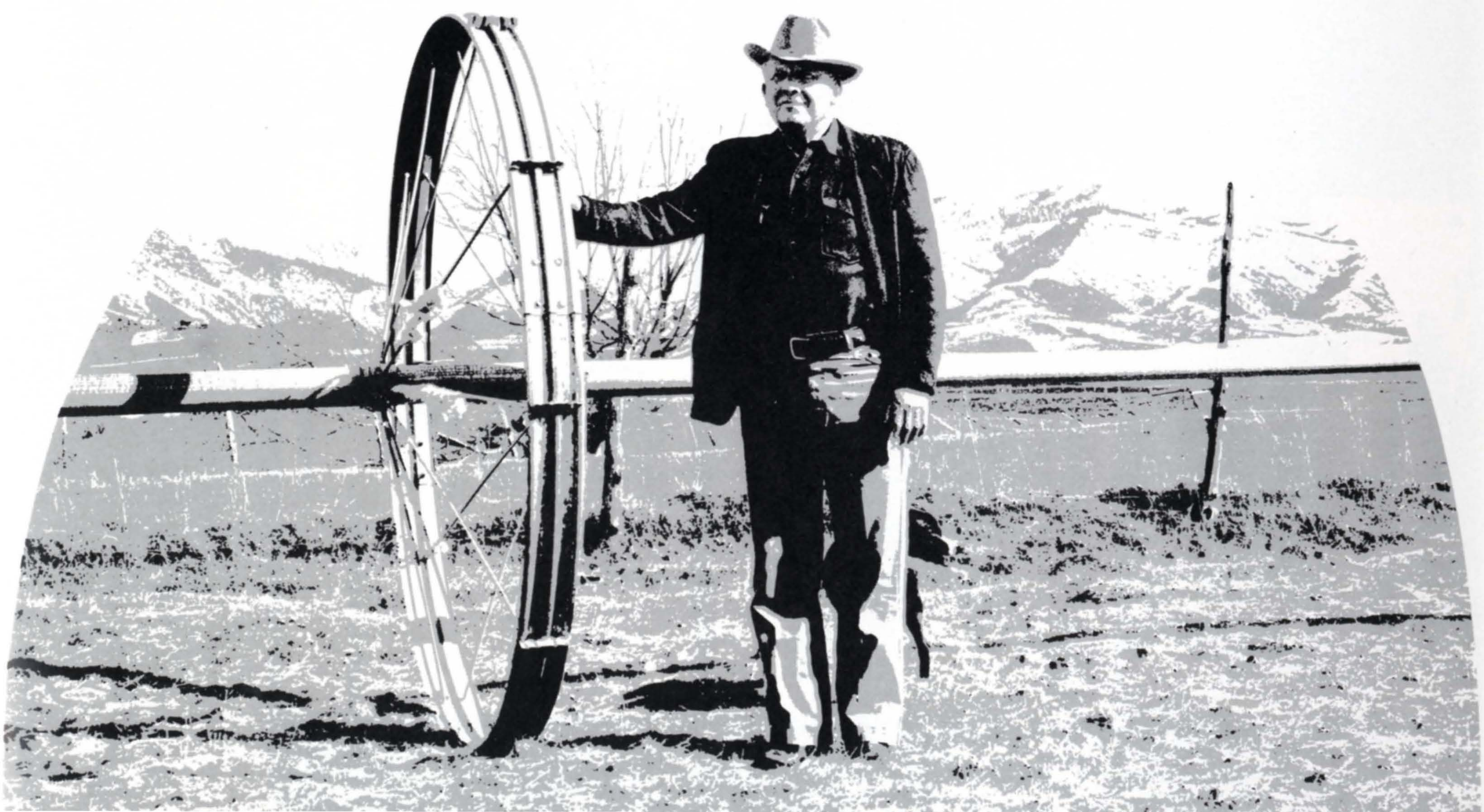


PHOTO AT RIGHT:

Ammophila wasp holds a common cabbage worm to ready it for storage. This individual made 13 nests of 8 caterpillars each in two weeks, which totalled 104 caterpillars destroyed. (104 x 2,000 wasp sisters = 208,000 fewer alfalfa weevils in your alfalfa field, cost free.)

PHOTOS AT LEFT:

1. The size and body style varies greatly among the wasps. Most tiny wasps are parasitic on eggs or larvae of other insects and thus are often used in biocontrol programs. The largest wasps, such as the tarantula hawk shown here, tend to catch or parasitize large insects.

Photo of wasp group by William P. Nye, Consultant/Collaborator Bee Biology/Sym Lab. USDA-SEA-AR, Logan.

2a. This adult Crabronid wood-nesting wasp is shown with its prey (flies). One egg is on the neck of the second fly.

2b. The wasps whose mud nests are such common sights throughout northern Utah provision their nests with spiders. The wasp larvae consume the spiders as they grow and develop into cocoon-spinning pupae.

3a. This painting of the Chrysididae wasp details the wasp's variety of colors.

3b. Armor plates serve to fend off attackers when the wasp rolls into a defensive ball.

Colored drawing from Walter Linsenmaier's book *Insects of the World*, published by McGraw-Hill Book Company, 1972.

4. By equipping this observation box with glass-tube nests, it was possible to watch within-nest activities of adults and the developing larvae and pupae.

5a. This particular Chrysididae genus parasitizes wasps that collect aphids. The larva in this photo is eating the provisions intended for the host larvae.

5b. The Chrysididae are also subject to parasitizing by other smaller wasps.

Photos by Frank Parker

WASPS

THE REAL STORY

REPUTATIONS—WHETHER GOOD OR BAD—rarely go unchanged by objective scrutiny. Idols have imperfections. Villains have admirable qualities. The same principle holds even in the world of insects.

Consider wasps as an example. Very few (five percent) of the more than 20,000 species found in the United States and Canada fit the prevailing concept of wasps as soft-bodied, relatively large insects equipped with stingers that are activated by nasty tempers. The truth is, better than 95 percent of all wasp species benefit human beings in some way (often by preying upon obnoxious insects such as aphids, cabbage worms, poisonous spiders, and cockroaches).

Relative to stingers, it is only the females of about 6,000 species who have them. In size, wasps vary from microscopic to six inches in length (Figure 1). Rather than being uniformly soft-bodied, some wear the same kind of hard external covering (chitin) as do beetles. And, what we see as nasty tempers, the wasps would probably call justifiable defense of their homes.

SORTING THEM OUT

To help make human-type sense out of waspish diversity, scientists categorize wasps into families. (Each family being a group of wasp species united by a common evolutionary ancestry.) To belong to a family, a species must construct nests in a particular way, using certain materials (e.g., digger wasps, potter wasps, paper wasps) (see next page). Species within a family tend to be either predacious *or* parasitic *or* plant feeders.

In 1977 and 1978, a graduate student at USU (B. V. Ouayogode) investigated species of the Chrysididae family of wasps that live in the Logan area. Like all wasps, these have four life stages: egg, larva, pupa, adult (three of which are shown in Figure 2); but, unlike the majority of wasps, the Chrysididae are armored. Their hard, beetle-like body covering brands them as parasites who lay their eggs in the nests of their hosts. Their larvae then thrive on the provisions left by the host species for *its* young.

The chitinous armor of the adult, nectar-consuming Chrysididae may be iridescent green, blue, red, gold, or some combination of these colors (Figures 3 a and b). In the United States, it is mostly green. The body covering is also of a fairly substantial thickness, to protect the wasps against chance encounters with their unwilling hosts during an entrance or exit from the host's nest.

According to Frank D. Parker,* Ouayogode's thesis director, the behavior and general biology of the Chrysididae are of interest because the Utah members of this family parasitize bees or wasps that people consider beneficial. In other words, larvae of the Chrysididae displace larvae of bees or wasps that either pollinate crop plants or prey upon insects that destroy crops. Selective control of the parasites that will not damage their hosts is unlikely to be achieved unless more is known about how the parasites operate.

*USDA Federal Collaborator

DEVELOPMENTAL CHARACTERISTICS

During his field (Figure 4) and laboratory observations of nine Chrysididae species, Ouayogode identified at least as many differences as similarities in their behavior and larval development patterns. The eggs might be laid on the host egg, or on the host's carefully stored pollen ball, or on developing host larvae (Figures 5 a and b). Several parasite eggs per host nest cell was a common occurrence, as was the ultimate survival of only one parasitic larva.

"Massive spray programs are detrimental to all of these beneficial insects. There is no assessment of their value— we only know that there are thousands of them, out there, unseen, working FOR us."

Once hatched, a parasitic wasp larva might initially be either active or passive. After they did become active, all the larvae were highly responsive to (defensive against) any disturbance. Larvae of most of the species studied began feeding immediately after hatching, but some underwent one molt before feeding. The larvae of one species was careful to locate and destroy the host's egg before beginning to feed on the provisions intended by the host for its own larva.

Physical changes in the Chrysididae larvae coincided with environmental alterations. For example, in its first stage, the larvae of all species wore a sort of helmet. The relatively tough covering over the head of a larva presumably helped protect it against attack by its siblings during a vulnerable time. The covering became much less obvious in later stages. Development of the larval mouth parts similarly matched a larva's needs at successive stages. From sharply pointed, curved, and hard (facilitating the hatching process and the puncturing of available foodstuffs), they became less curved and formed teeth as the larva's food changed from primarily liquids to solids.

BEYOND CHRYSIDIDAE

As Parker pointed out, the two years of work by Ouayogode have provided just a start toward a management understanding of the Chrysididae. And there are dozens of other species of wasps about which even less is known. Some of these are unobtrusive guests in gardens throughout the United States.

In Utah, a home gardener who wants to encourage wasps to help in the unending effort to control insects that destroy crop and ornamental crops, should provide nesting opportunities (Figures 6 a and b). For example, if the target is wasps such as *Euodynerus,* which collect insect larvae (caterpillars) that feed on fruit tree and shrub leaves, the starting point is a block of wood about 4 x 6 inches. The wood should be drilled with holes 3 to 4 inches deep and 1/16 to 1/2 inch in diameter. The drilled block of wood should be placed in a protected area of the garden (in trees or under eaves), or on a post with a flat piece of plywood nailed on top to shelter it from sun and rain.

Each hole in such a block will accommodate eight nest "cells," and each cell is characteristically provisioned with about 10 paralyzed, leaf-eater larvae. That means an average nest block will have eliminated several hundred caterpillars.

To wage war on aphids, a gardener should collect pithy stems (e.g., of elderberry, sumac, or raspberry). The stems should then be stuck into the ground in sunny areas, with the cut end in the air. Aphid-collecting wasps will build about 20 nest cells per stem, and place 50 to 75 aphids in each cell.

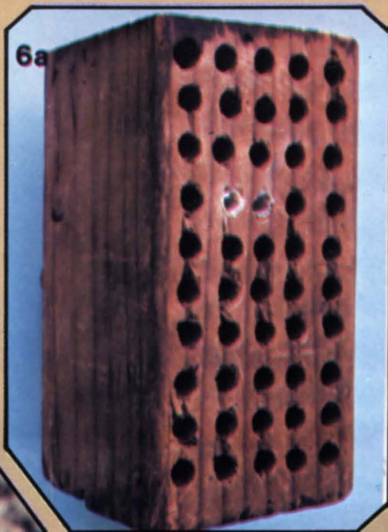
The same kind of stems can be cut into 10 inch lengths, the centers removed with a cork bore, and taped into bundles of about 10 stems per bundle. When these are attached to tree limbs they will serve as nests for (and therefore attract) other wasp types that collect those same garden pests and/or flies, spiders, crickets, and leaf hoppers.

Some wasps undeniably tend to fulfill the image held by most people. But that minority group should not keep us from recognizing (and even exploiting) the useful aspects of the majority.

6a. Nesting boxes are equipped with wax-free straws to encourage habitation.

6b. Wasps will nest in hollow sticks which are driven into the earth at the margins of fields.

7a. *Odynerus* wasp provisions her nest with alfalfa weevils. Nests occur by the thousands in colonies near alfalfa fields.



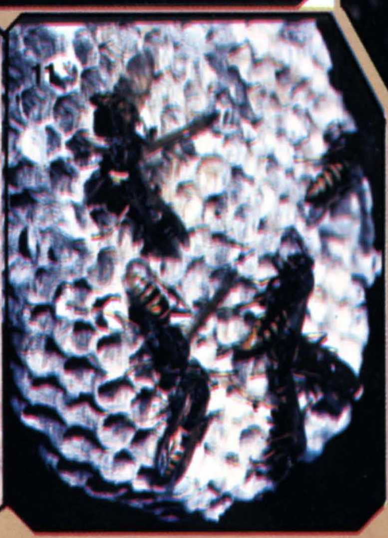
9a. The tachytes wasp prefers grasshoppers. Here she digs the nest in which she will place paralyzed grasshoppers.

9b. The tachytes egg is apparent on the neck of the stored grasshopper.

10. Wasp larva here feeds on a crab spider. The crab spider hides in flowers and preys upon pollinators.

7b. Larvae are paralyzed by the wasp's sting and packed into underground nests to provide food for the young wasps.

8. These *Sceliphron* cocoons laid side by side in earthen cells were found in Millville.



11. Paper wasp, long considered an annoyance, uses many caterpillar species as food. The wasp selectively "butchers out" only the finest parts, chews them up, rolls them into a ball, and feeds her young in the same fashion as do birds.

Photos by Frank Parker

IPM for better use of insecticides

IPM—A "BUZZ WORD" OF MODERN AGRICULTURE, is beginning to touch farmers in Utah and elsewhere in the West. IPM is "Integrated Pest Management" and it has been very successful in some ways. Take insecticide use for example. In some alfalfa seed fields of Millard County, Utah State University pest management programs have lowered the number of average insecticide applications needed per season. In alfalfa, the results of better management can be striking. It is estimated that 80 percent of Cache County alfalfa fields were sprayed in 1970, 20 percent were sprayed in 1978, and two percent in 1979. The unsprayed fields produced well without insecticide help in 1978 and 1979 because beneficial insects left in the fields and cultural practices held pest populations in check.

IPM's successes are based on established concepts that wise combinations of cultural, biological, and chemical control measures will efficiently reduce pest populations. Pest populations, scientists have learned, need not always be eliminated, but they do need to be reduced to a point where crop income losses do not exceed the cost of control. In Utah's alfalfa fields, this has usually been done by timing the first cutting to disrupt the alfalfa weevil life cycle and optimize the effects of any beneficial insects in the fields. There are circumstances in alfalfa and many other crops, however, that require insecticide applications as important parts of IPM recommendations.

Currently, IPM utilizes two principles. First, insect (pest and beneficial) populations may be predicted by observing temperature accumulation and other factors throughout the season. Second, data important to IPM decisions are collected and used (in the field) by those concerned, with guidance provided by IPM scouts or consultants trained by Agricultural Experiment Station scientists.

Bill Brindley

Diefalla Osman fills his test vials with grass and grass bugs to determine insecticide toxicity.

The IPM testing program provides an opportunity for intelligent insecticide use. It is applied ecology for the farmer.

The Missing Factor

Scientists have known for many years that insects differ in their susceptibility to insecticides according to their sex, age, and where and when they are treated. The catch was that the susceptibility could not be measured in a practical way at the farm level by IPM scouts. Cases of insecticide resistance (when no control would be achieved from insecticide application) thus would be discovered only by sad experience.

At USU, however, William A. Brindley (Associate Professor of Biology) and Diefalla H. Osman (a graduate student) developed a method whereby pest insect susceptibility to the insecticide of choice *can* be measured on the spot. The susceptibility of alfalfa weevils, black grass bugs, and a number of other insects—both pest and beneficial—to insecticides can now be measured prior to applications.

Bill Brindley

Sweeping with a net allows the specialist to analyze the insect populations and to collect insects for the bioassay test.

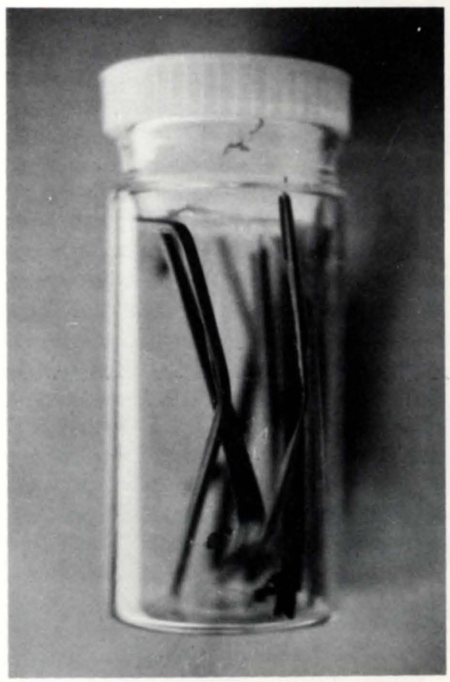
How It Works

What if you, as an agriculturalist or pest management consultant had to answer the question: "Why didn't they die?" asked after a field had been sprayed but alfalfa weevils were pouring out of the bales at harvest. Scientists formerly would provide an answer with an extended and expensive study in a complete laboratory. But with the Brindley/Osman approach, a simple test kit of insecticide-treated vials can answer that practical question within 24 hours.

In one specific case, of a few years ago, a field sprayed with an organophosphate still had an alfalfa weevil population. By using the test kit, the investigators found the insects in that field were no less susceptible than ones in fields where control had been achieved. Those results, available the next day, led to a reexamination of the farmer's procedures and showed the insecticide had not been applied correctly.

The USU testing procedures have also been tried with three species of grass bugs—one of which is an agricultural pest, while two are not. Grass bugs, like other insects that feed on plant sap, are often difficult to handle in laboratory research. But with the new biological assay techniques, it can be quickly and easily demonstrated how the grass bug populations differ in insecticide susceptibility (according to species, sex, location, and season). Then conclusions can be drawn about the biochemical reasons for the differences.

IPM is an effective approach to easing pest problems. It has been useful in reducing insecticide applications and improving the ability of farmers to manage their fields to achieve particular results. Now, when insecticide applications are recommended, IPM adherents have a technology that can give additional guidance to their insect control decisions.



Test vial treated with insecticide contains site samplings of grass and insects to be analyzed.

PROJECTS IN PROGRESS

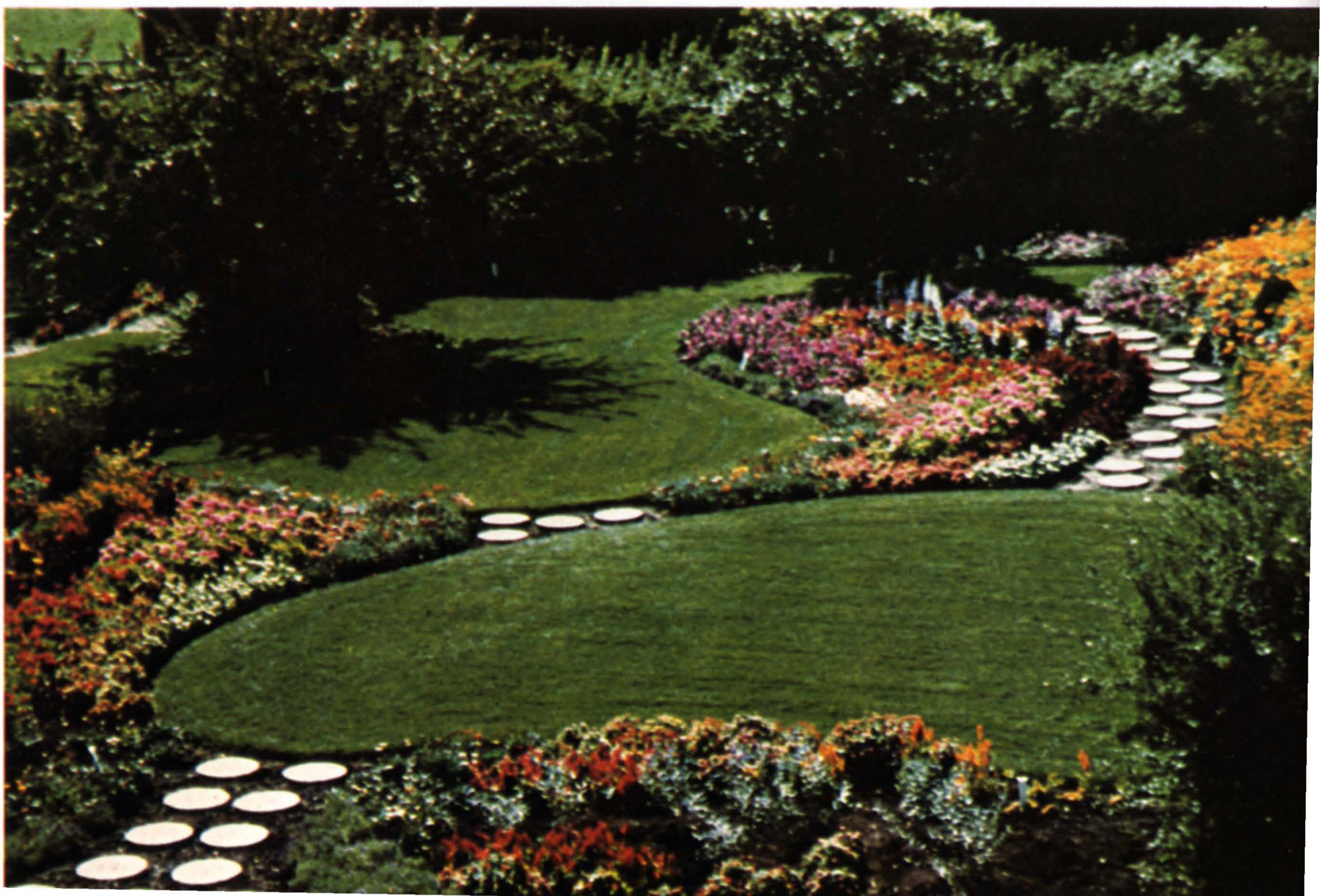
HELP— FOR YOU AND YOUR YARD

"AS PERPETUALLY IN PROGRESS as any project can be." Few would argue with that description of the Farmington Display Gardens.

Located at the intersection of Highways 89 and 91 (just north of Lagoon), the Gardens have been a source of information and inspiration to Utah's do-it-yourself landscapers and gardeners for 20 years. Available without charge to the public, the Farmington collection of trees, shrubs,

Bill Varga points out ideal placement of suitable plants for this area.

Beautiful landscaping requires a working, integrated knowledge of plants, soils, climate, and land contours.



flowers, and ground covers is under continual review and revision. Some changes are subtle, some are glaring—some occur overnight, others come with the seasons, or take place as part of long-term development plans.

Currently directed by Alvin Hamson and William (Bill) Varga, the Farmington Display Gardens have been designed to help Utahns from Logan to St. George solve their landscaping and gardening problems. The Gardens have been arranged to allow visitors to see how specific flowers, herbs, shrubs, and trees look in yard-size settings. Visitors can use the plant labels as their guides and go on their own individual tours, or they can pre-arrange for an accompanied viewing of the approximately 7-acre area. (A 2-acre vegetable garden and a comparative test planting of a University of Utah oak-breeding experiment are across the road.)

Successive visits to the Gardens can be used to see how a landscape changes through the seasons. And because the Gardens have been established for so many years, they also give visitors a chance to see how various plants are likely to mature.

Asked about plans for the 1980 season, Varga replied, "For one thing, we are devoting one area to dwarf fruit trees, berries, grapes—the kinds of food-bearing plants an average backyard can accommodate. The other major development will be a native-plant garden. We will concentrate on presenting the natives that are (or are likely to become) available as nursery stock. But we'll also include some of what are now considered exotics, species that would be difficult to find commercially. All of these plantings will be north of the new Visitor Pavilion and parking lot."

In combination with the ongoing varietal tests and displays, the 1980 developments will further extend the Farmington Display Gardens' potentials as a practical reference point. Potentials that more and more Utahns are recognizing and taking advantage of on a regular basis.

A family field trip to the Farmington Display Gardens offers enjoyment and new knowledge.

BEEF AS A SCIENCE

WE'VE COME A LONG WAY since the days of cattle drives, cowboys packing six-shooters, prolonged aging of carcasses, and the neighborhood butcher. Beef production has become a many-stepped industry that usually takes animals through: a range or pasture growth phase; feedlot weight gains; slaughter, short-term aging, and packaging; and supermarket display counter, enroute to the consumer.

The result, for the consumer, has been a year-round availability of beef of consistent quality. For individual scientists trying to help those operating at the various production levels become more efficient, the result has been general frustration. The interactions among variables are just too complex for anything less than comprehensive, long-term, costly research that requires a blend of several kinds of expertise.

So researchers have turned to regional cooperative efforts that cut costs while boosting the likelihood of producing widely usable data. One such program has had USU's James A. Bennett and his graduate student, Gina Campbell, working with personnel from Arizona, New Mexico, Texas, and the USDA. Begun in 1975, the research has one more year to go, but it has already generated information needed by members of the beef industry.

Thanks to their cooperative approach, the scientists have been able to compare breeds, ages, and biologically different types (frame sizes) of cattle relative to performance (rates and costs of gain) in pasture and feedlot. Through the years, they have also carried the study into comparisons of carcass yields and grades as these relate to feeding regimes, age of animal when put on concentrates, and diets (high, medium, and low concentrate rations), with consumers and taste-test panels providing the ultimate evaluations of meat quality.

Part of the motivation for the work, according to Bennett, was to "...see if consumers will accept beef from animals fed mostly roughage. As more grain-producing acreages go into grains for human rather than feedlot consumption, and/or if large-scale gasohol production from grains becomes a reality, today's beef-feeding practices may have to be drastically revised. We wanted to define the lowest level of concentrates (grains) that might affect consumer perceptions of flavor and tenderness."

Bennett went on to comment, "In one completed phase of work, we found that different quantities of grain did not affect consumer acceptance so long as all the animals were fed to attain .4-inch of backfat. We also found that feeding concentrates for a mere 60 days gave beef the flavor consumers want."

Among the other insights that have come from the completed years of the program are: Individual animals within each of the frame-size classes were able to make highly efficient gains. Carrying the cattle to more than .4-inch backfat (regardless of diet) wasted time and feed in terms of final body weight and carcass yield. Also, current prices for grain and roughage indicate that (for now, at least) diets of 25 percent or less roughage are the most economical.

By the time the 1980 experiments are finished and the data from all five years are correlated and analyzed, beef producers in every phase of the business can expect to know a great deal more than they did about optimizing profits while keeping beef consumers satisfied.

RANGELAND: NEW DIMENSIONS/NEW DECISIONS

ONCE UPON AN UNSOPHISTICATED TIME, the management of publicly owned rangelands seemed a fairly simple matter. Vegetation production had to be balanced with grazing pressure (with primary consideration given to livestock), and grazing was to be managed to promote long-term forage availability.

Then came wider understanding of, and support for, the multiple-use concept. Shortly thereafter, the realities of a food- and energy-short world further revised rangeland value systems. Simultaneously, scientists were identifying more and more of the variables that function in the production capabilities of range. As a result, by the late 1970s, managers of rangelands were expected to work toward optimizing all facets of range production (livestock, deer, elk, nongame birds and mammals, water, forage, and recreation).

In Utah, as in most of the Intermountain West, foothill ranges are especially crucial to such a goal. Since the amount of forage on a range defines many of its other potentials, efforts to increase the quantity and quality of forage are popular with land managers. The problems come when the methods used to increase the forage base have unexpected, damaging side effects on the land as a watershed, or on the survival of native animal and/or bird populations.

One starting point toward identifying and avoiding detrimental side effects is the accumulation of data that describe the situation before anything is modified. Philip J. Urness of the Range Science Department elaborated on that truism by saying, "We know that altering range vegetation (as by removing brush and seeding to grass) affects not only the vegetative cover but also the other products and inhabitants of the land. What we don't know, is precisely what these effects are—and we are even less aware of just how and when they take place during a season or a series of seasons."

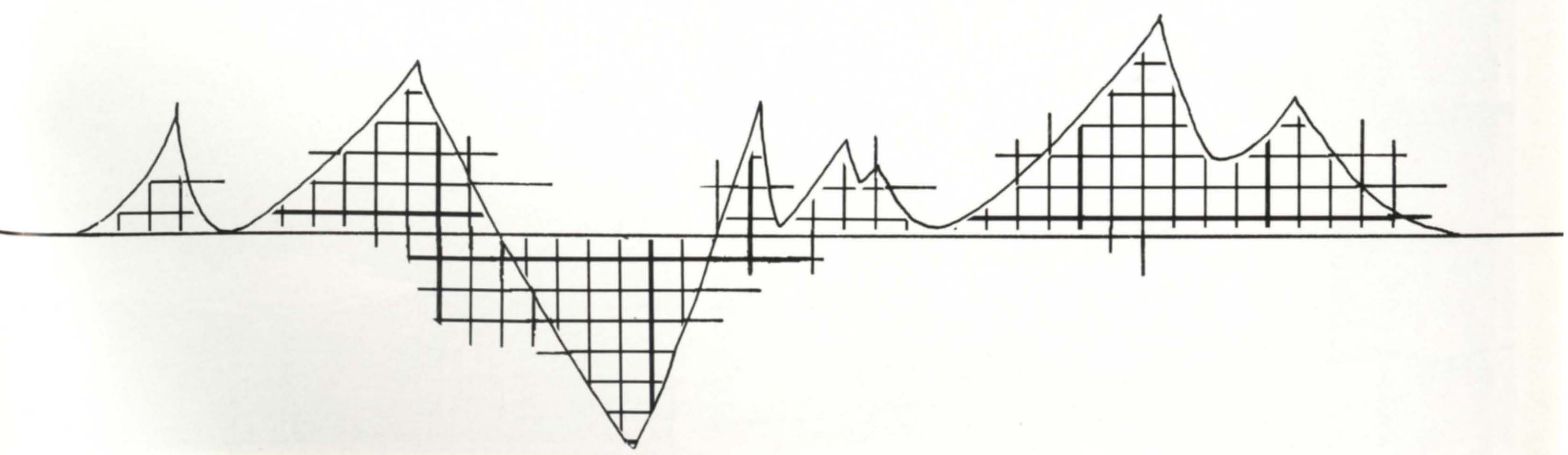
Urness went on to note that the Tintic Research Pastures near Eureka in Juab County are representative of large acreages of Intermountain foothill range. Managed cooperatively by USU and BLM personnel, the 24 contiguous 28-hectare pastures are the site of a 10-year investigation that will provide much of the needed data.

A graduate student (Courtney Smith) currently is sharing responsibility with Urness for one of the ten coordinated research projects that began at Tintic in 1978-79. "What we are working with," said Smith, "are areas that were seeded to wheatgrasses about 20 years ago, after sagebrush and junipers had been removed; and areas of non-seeded, native vegetation. Both types have been consistently open to annual cattle grazing in the spring and early summer. Our goal is to find out what kinds of relationships exist right now among vegetation types and populations of nongame mammals (cottontail and jack rabbits; pocket, deer, and harvest mice; and other rodents) and birds."

"Before we can evaluate changes, we have to know what is there under today's conditions," explained Urness. He went on to say, "That means we've had to start with a census-taking operation, using live traps and marking systems for the rodents and visual observations for the birds. We began with the idea of comparing differences in populations between the seeded and non-seeded parcels of range."

"Instead," injected Smith, "we found that the alternating pattern of seeded and unseeded units at Tintic, plus extremely mobile small mammals, made between-unit comparisons impractical. We've also seen more diversity in bird life through the year than we'd expected. Because of the way it was designed years ago, Tintic thus gives its small-mammal and bird populations access to a habitat complex. We are now thinking in terms of contrasting small-mammal and bird use of that complex, with the use made of adjacent, relatively monotypic vegetation."

Whatever Urness and Smith learn about the rangeland ecological interdependencies of large grazing animals, vegetation types and forage availability, and small mammal/bird populations will be integrated with data from the other research projects that are in progress at Tintic. The insights derived can then be put to use enhancing the quantity and quality of products reaped from Intermountain foothill ranges.



THE QUIET ONES IN ROOM 240

MOST INHABITANTS OF ROOM 240 in USU's College of Science never disturb one another—or their neighbors down the hall. They move only with help; their communication is always indirect. Despite their inability to socialize, however, their visitor rate is remarkably high.

How and why does this paradoxical situation persist? Because room 240 houses USU's Entomological Museum, which is the final resting place for approximately one million insect specimens as well as a work room for staff and students. Ranging in size from microscopic to several inches in length, the insects are used in: research projects, solving identification problems, and educating students and the general public.

"We have one of the most complete collections in the West," said Wilford J. Hanson, Associate Professor of Biology and present curator of the museum. In talking about the museum's history and objectives, Hanson explained that systematic collecting began in the 1890s, with an emphasis on crop pests.

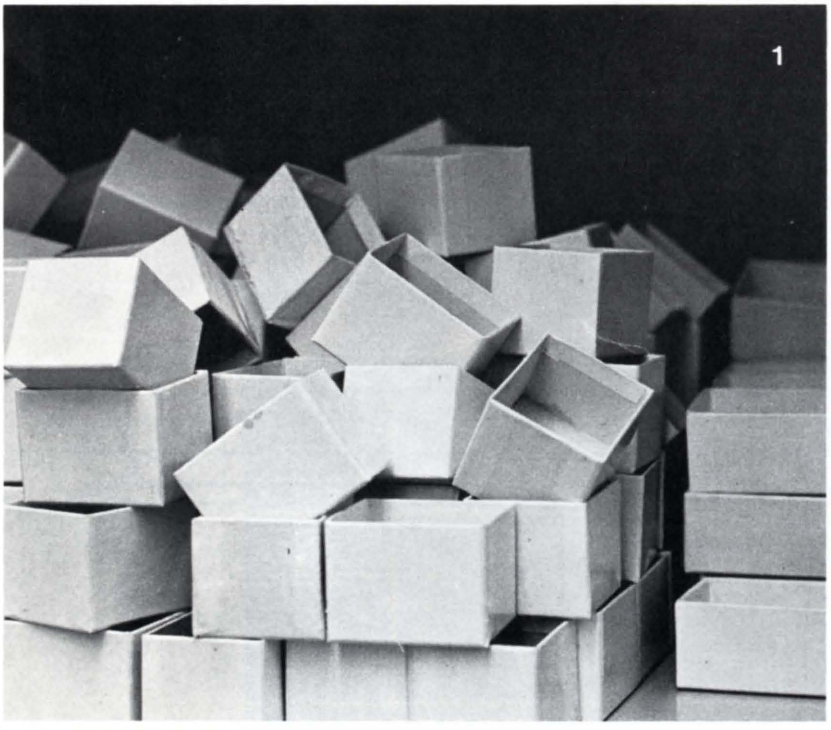
"But expansion was slow," he said, "until the mid 1920s, when G. F. Knowlton joined the staff. Largely by using his free time, he made an intensive effort to sample insect life throughout Utah. Knowlton's investment of time and energy moved the museum's major objective—representatives of all Utah species—out of a wild-dream category into a maybe-we-can-do-it stage."

As Hanson was quick to admit, however, the objective will still require substantial time to achieve. Complicating factors include self-propelled insect migrations, inadvertent (or deliberate) introductions of insect species by people and their activities, and the ubiquitous use of insecticides in recent years. The state's insect populations are thus kept in flux, and the objective of a completely representative collection remains elusive.

"But even so," said Hanson, "our specimens, especially those from groups known to attack crops, forest trees, and livestock, are certainly representative of the important and abundant insects currently living in Utah. Our samplings of Utah's insects, when combined with the USDA collection of bees, and our specimens from such areas as Africa, the South Pacific, and Central and South America, give us at least a modest start on the world's one million or so insect species."

To the uninitiated, the drawers upon drawers of dry- and wet-mounted insects in room 240 might seem to exemplify finished rather than in-progress work. In reality, their use as reference material, sporadic updating with new specimens, and regular checking to be sure their contents aren't being cannibalized by free-roaming relatives, keep the drawers in a perpetually in-progress state. Certainly the work/study university students and 4-H volunteers who help process newly collected specimens into their proper drawers have no doubts about the dynamics of USU's Entomological Museum.

Photos by Mike Jackso



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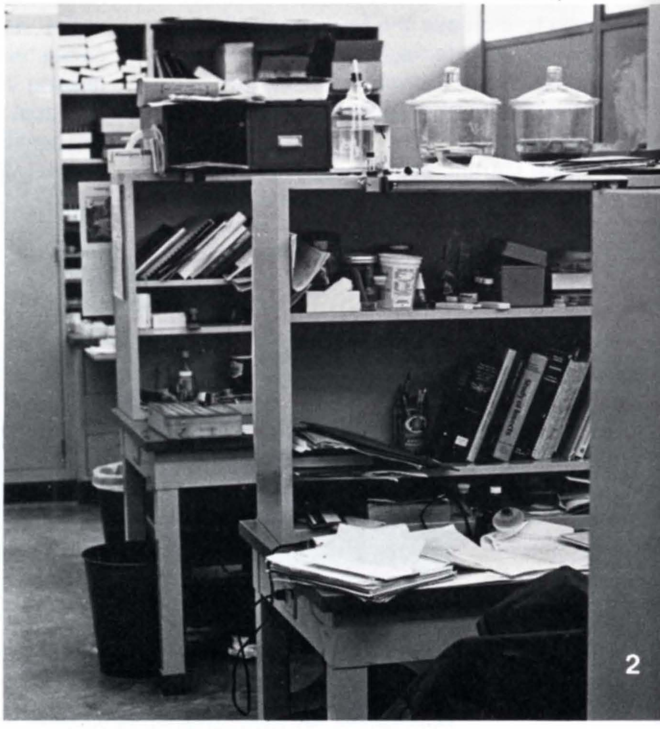

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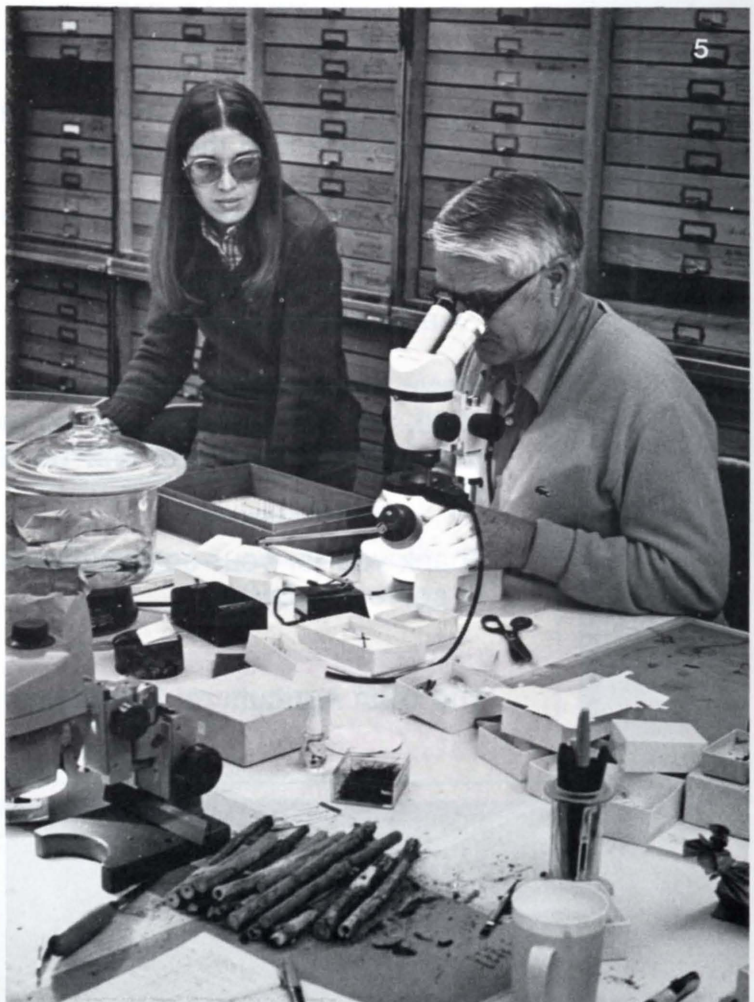
PHOTOS AT LEFT:

Specimen boxes (far left) are quickly filled with insects by students and faculty (1). The student study area (2) partially surrounds the collection cabinets which are filled with drawers of mounted specimens. Dr. Hanson, curator of the museum, displays exotic walking sticks from Central and South America (3). Wide tables are used to spread out materials needed for study, like these hollow sticks filled with wasp larvae (4). Faculty members give valuable assistance to student projects with the help of taxonomic references offered by the collection (5).



UTAH SCIENCE

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UTAH SCIENCE is a quarterly devoted to research in agriculture, land and water resources, home and community life, human nutrition and development, and other wide-ranging research conducted at Utah State University. Published by the Agricultural Experiment Station, Utah State University, Logan, Utah 84322.

The magazine will be sent free on request.

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